

**An-Najah National University
Faculty of Graduate Studies**

**Effect of Snow Fall on Steel Structures in
the West Bank- Risk Assessment Study**

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Requirements for the Degree of Masters of Engineering
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Effect of Snow Fall on Steel Structures in the West Bank- Risk Assessment Study

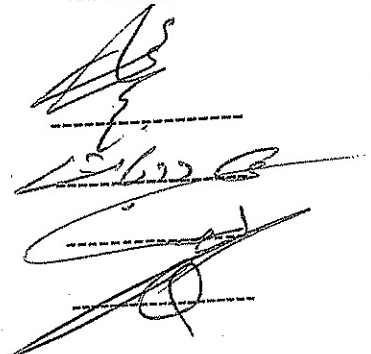
By
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Signature



Dedication

“To my parents... Amani & Nidal”

Who raised me to be the person I am today

Acknowledgments

First and foremost I am extremely grateful to Almighty Allah for what I am and for everything I have, for all the support granted to me. This effort would not be reached without God's limitless guidance and help.

The recognition of this work was only possible due to several people's collaboration, to which I desire to express my gratefulness.

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This thesis is only the beginning of my journey.

الإقرار

أنا الموقعة أدناه، مقدمة الرسالة التي تحمل العنوان:

Effect of Snow Fall on Steel Structures in the West Bank- Risk Assessment Study

أثر تساقط الثلوج على المنشآت المعدنية في الضفة الغربية دراسة في تقييم المخاطر

أقر بأن ما اشتملت عليه هذه الأطروحة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة كاملة، أو أي جزء منها لم يقدم من قبل لنيل أي درجة أو لقب علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى.

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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Date:

التاريخ: ٢٠١٦ / ٧ / ٢٠

List of Abbreviations

PCBS	: Palestinian Central Bureau of Statistics
UNEP	: <i>United Nations Environment Programme</i>
UNDP	: <i>United Nations Development Programme</i>
IPCC	: Intergovernmental Panel on Climate Change
ARIJ	: Applied Research Institute – Jerusalem
NCA	: National Climate Assessment
CC	: Climate change
NCDC	: National Climatic Data Center
NOAA	: National Oceanic and Atmospheric Administration
LSAT	: Land Surface Air Temperature
MENA	: Middle East and North Africa <i>region</i>
NSC	: National Standards of Canada
ISO	: International Standard Organization
AR5	: Fifth Assessment Report
AR4	: Fourth Assessment Report
RA	: Risk Analysis
ERA	: Environmental Risk Analysis
HI	: Hazard Identification
TAR	: Third Assessment Report
RCP's	: Representative Concentration Pathways
CP	: Climate Prediction
EMME	: Eastern Mediterranean and the Middle East
FT	: Fault Tree analysis
ET	: Event Tree analysis
EIA	: Environmental Impact Assessment
BT	: Bow Tie model
EIS	: Environmental Information System
DRR	: Disaster Risk Reduction
WB	: West Bank
UBC	: Uniform Building Code
PMS	: Palestinian Meteorological Station
FEMA	: Federal Emergency Management Agency

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Abstract

Climate change affected Palestine in the last few years and caused different losses and damages. The West Bank were affected clearly by extreme snow fall which caused significant losses in different aspects giving attention to what could be the outcomes in the next years.

Adverse effects that result from the accumulated snow fall were manifested in several directions such as in the agricultural, commercial, economic and construction sectors. The effect was obviously viewed and steel structures encountered different problems. Constructions were confronted high loads that were not used to be considered before and caused lots of losses. This research was made due to the importance of studying how to mitigate the adverse effect of increase in snow fall in the coming years and to respond to any similar risks quickly.

The importance of this research is to have better understanding of the climate change effects- snow effect as a case study on steel structures especially in the West Bank and studying the risk that may affect steel structures and results from different aspects such as the unexpected snow fall (natural events), the instability of the structure - not designed with

bracing (man-made events) or a combination of the previous events which may affect structures and caused failure. It is also important for decision makers to adopt the best management strategies and practices in minimizing and mitigating the negative consequences resulting from increase in snow fall.

Different objectives through the research were achieved started by studying the effect of frequent snow accumulation on design and building construction in the West Bank, computing the snow loads on steel structures based on current codes. Also, evaluating the future risk that may result from that excessive event by identifying threats, hazards and consequences. Finally, proposing risk management options, to mitigate hazards for such risks.

Structural and risk analysis were mainly carried out in this research, for the structural analysis, two main cases were chosen to be analyzed and checked, the first case was Jamaeen stone cut truss and the second one was the Italian company for marble, although their roofs were analyzed using SAP 2000 software and designed using snow load as per the Jordanian Code, the analysis shows that the roof is safe, the roof failed in reality and that may make the current using codes for computing snow load unsafe under certain circumstances. Thus, modification factors are needed. For risk analysis, the snow fall over steel structures risk were analyzed by identifying the risk, its causes and consequences by using the Bow tie and matrix risk analysis tools. After that risk evaluation and control measures

that help making decisions based on the outcomes of the risk analysis such as removing the accumulated snow before, during and after the snow were suggested.

Finally, risk management options so as to mitigate and adapt hazards in order to improve the preparedness and response were proposed such as recommending a future risk mapping and zoning, also, increasing the public awareness by training, education around threats and hazards, moreover, to improve emergency response capacity as civil defense capacity.

Chapter One

Introduction

Chapter One

Introduction

1.1 Background

Climate change is no more an illusion, its effect was observed over the world and its negative impacts will be witnessed clearly in the coming years. Regional and national interferences should be addressed to respond its unfavorable impacts at high levels. Also, governments and communities have to react quickly to this event in order to minimize the adverse effect of climate change and raise the flexibility of local communities to cope with it (UNDP, 2010).

State of Palestine, as part of the Middle East, have been and will be subjected to many serious climate changes that include increases in temperature and sea level rise, changes in snow fall amounts, reduction in the annual rainfall also hydro-meteorological dangers such as heat waves, droughts, floods, storms. These physical impacts may cause failures in many societal and economical aspects (Salem, 2011). According to (UNEP, 2003): "The Middle East is a meeting of many escalating environmental threats, additional problems of scarcity of water resources and land, rapid population growth, climate change and desertification."

It is well known fact that some of these effects may not necessary be negative, but all effects need to be evaluated as early as possible in order to deal with any sudden situation in short time. Rain and snow are important

components of the earth's climate system and are particularly sensitive to global warming (Jain et al., 2009).

1.2 Problem Statement

Climate change affected the constructions clearly in the last few years in Palestine and caused different losses and damages. The West Bank, witnessed a heavy fall of snow, which gives attention to what could be the outcomes. Adverse effects were manifested in several directions such as in the agricultural, commercial, economic and construction sectors. Constructions confront high loads that were not used to be considered before and caused lots of losses, especially in steel structures.

The accumulated snow fall effect was clearly viewed. The country was not expected that amount of snow fall, therefore steel structures encounter different problems, several steel structures were affected by the recent extreme snow fall such as Jamaeen stone cut, Geneva Company and the Italian company. Some pictures of the failure of these structures are shown in (Annex B).

This research was made in order to study the effect of snow fall on steel structures in the WB and how to cope with it. Also, it was made due to the importance of studying how to mitigate the adverse effect of increase in snow fall in the coming years and how to respond to any similar risks quickly.

1.3 Research Statement

The importance of this research is to have better understanding of the current status of climate change - snow effect as a case study on steel structures especially in the West Bank in order to evaluate the current snow load based on current codes and standards. It is also important for decision makers to adopt the best management strategies and practices in minimizing and mitigating the negative consequences resulting from increase in snow fall.

1.4 Research Objectives

The main objectives of this research are:

1. To evaluate snow load based on the current codes of practice.
2. To study the effect of frequent snow accumulation, on design and building construction in the West Bank.
3. To estimate the potential future risk that results from extreme snow fall, by defining threats, hazards and expected consequences.
4. To propose a risk management options, to mitigate hazards for such risks.

1.5 Thesis structure

The thesis is organized in five chapters as shown in Figure (1.1).

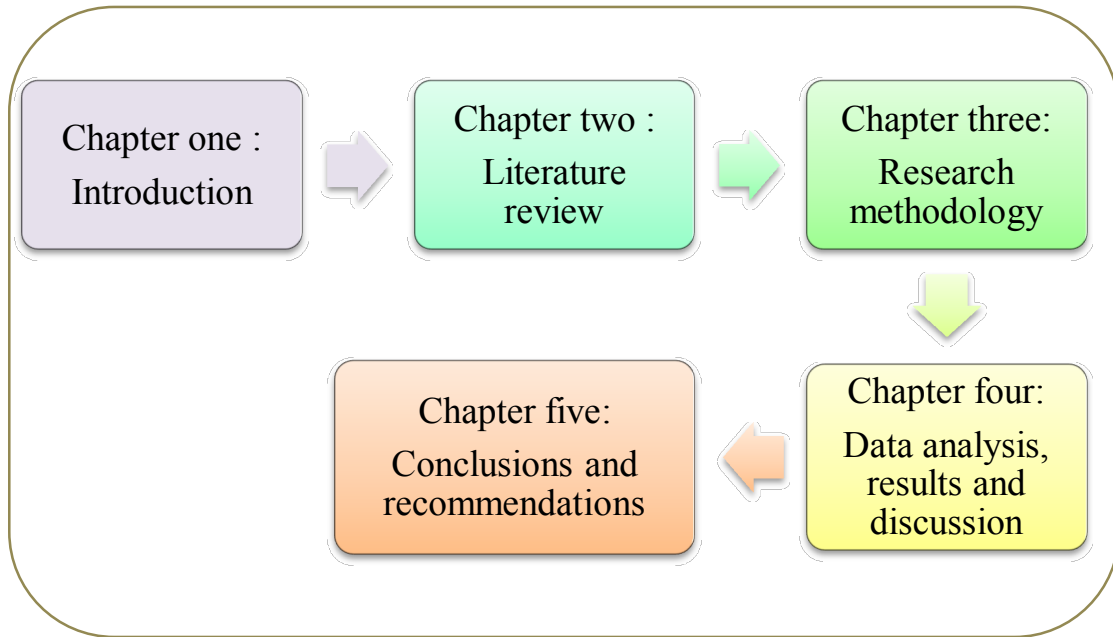


Figure (1.1): Architecture of the thesis

In Chapter 1, it presents the introduction of this research with a brief illustration of the study. It also covers the importance and objectives to support this research.

In chapter 2, an intensive literature review was conducted from the climate change to the climate change risk then the definition of risk and how to assess and manage risk. In addition, a broader view was taken to look into how climate change extremes events such as extreme snow fall could affect steel structures and how to manage it in different ways. Thereafter, risk assessment was analyzed, which lead to the methods that will be used for this study.

The research methodology which consists of the research problem, data collection method and data analysis techniques are outlined in Chapter 3.

In Chapter 4, the results of the data collected through interviews are presented using data display and analysis techniques that are described in the ‘Methodology’ section. This chapter is divided basically into the structural analysis and risk analysis then ends with the illustration of how to assess and manage the accumulated snow loads on steel structures risk.

Finally, chapter 5 abstracts the thesis results through conclusions. Also, the chapter indicates recommendations for the research, and includes suggestions for future studies.

Chapter Two
Literature Review

Chapter Two

Literature Review

2.1 Climate change

Climate usually measured over a period of several decades, and defined as: long-term variations and averages in weather. The Earth's climate system includes the land surface, oceans, atmosphere and ice (NCA, 2014).

Climate change refers to “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties” which remains for an extended duration of time. Since about 1850, climate change was examined for the period with instrumental observations (IPCC, 2013).

Global climate trends are changing rapidly, and human is marked as the primary drivers of the change in origin. Figure (2.1) illustrate the evidence for a change in the climate system abounds, from the top of the atmosphere to the depths of the oceans. Scientists and engineers over the world have collected this evidence using several observing systems in order to monitor the Earth's climate. These systems are: satellites, thermometers at surface stations, weather balloons and other types (NCA, 2014).

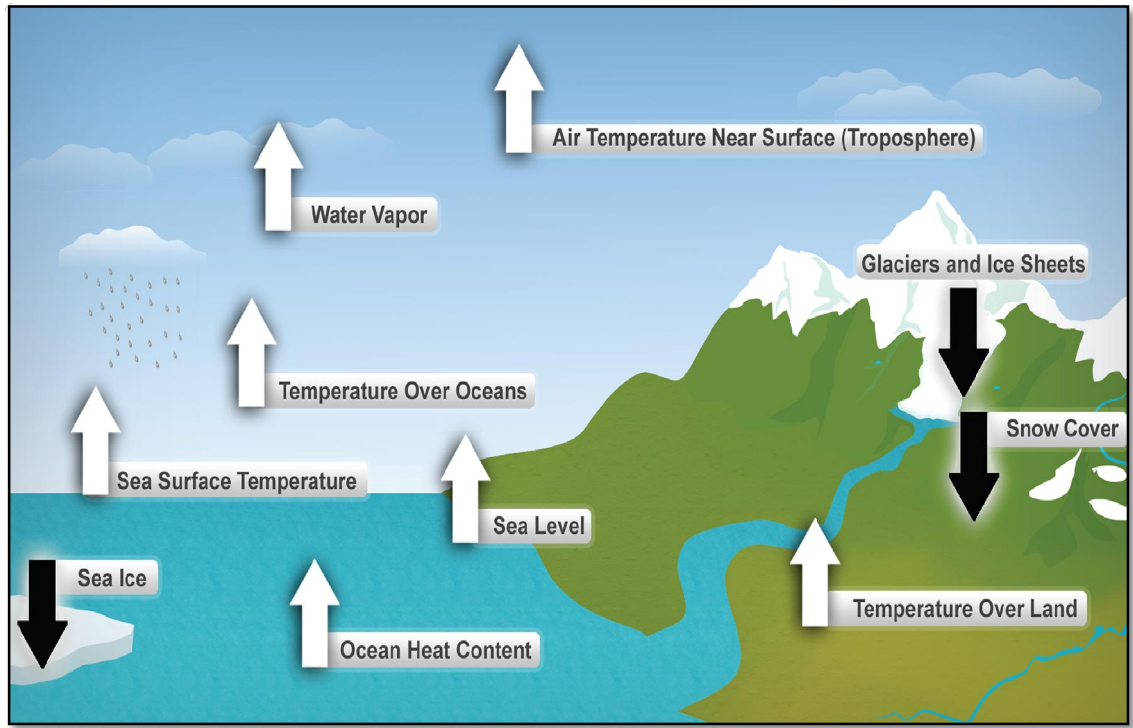


Figure (2.1): Ten indicators of a warming world/CC.

Source: (NCDC NOAA, 2016).

To conclude, Figure (2.1) presents some indicators were measured globally for many decades showing clearly that climate is changing and the Earth's climate is warming. White arrows express an increasing trend, and black arrows express decreasing trend. All the indicators expected to increase in a warming world are, in fact, increasing, and all those expected to decrease in a warming world are decreasing (NCA, 2014), (NCDC, 2016).

2.2 Observed trends evaluation

This section addresses the global observed trends of temperature and precipitation basically.

2.2.1 Observed trends in the global climate change

a. Temperature:

The overall evidence tells an obvious story: the planet is warming (NCA, 2014).

Over the last 100 years, the global mean surface temperatures have risen by $0.74^{\circ}\text{C} \pm 0.18^{\circ}\text{C}$ when estimated by a linear trend. The rate of warming over the last 50 years is almost double to be about ($0.13^{\circ}\text{C} \pm 0.03^{\circ}\text{C}$ per decade) that over the last 100 years ($0.07^{\circ}\text{C} \pm 0.02^{\circ}\text{C}$ per decade) (IPCC, 2007a). Eleven of the last 12 years (1995 to 2006) rank among the 12 warmest years on record since 1850 (IPCC, 2007a).

Figure (2.2) shows the observed global annual average Land-Surface Air Temperature (LSAT) from 1850 to 2012 relative to 1961–1990 climatology from the latest versions of four different data sets.

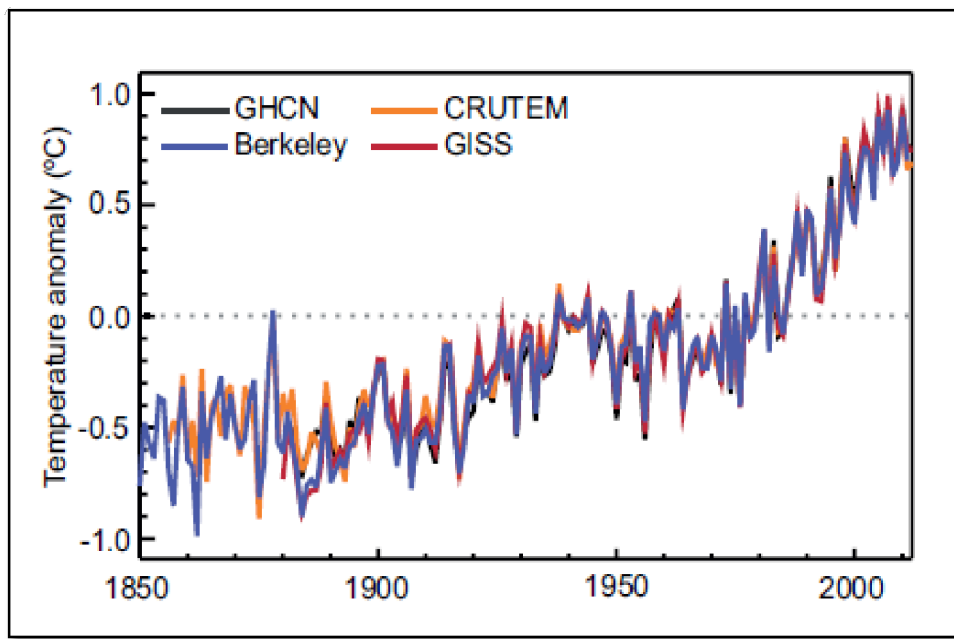


Figure (2.2): Global annual average land-surface air temperature.

Source: IPCC, 2013.

Table (2.1) shows the estimated trends for LSAT global average values over several periods from 1880 to 2012. Although there are a lot of approaches, trends and long-term variations, all of them are broadly agree with these various LSAT estimates, particularly after 1900. Global LSAT has increased (IPCC, 2013).

Table (2.1): Increasing trend of LSAT global average values over four periods.

Data set	Trends in °C per decade			
	1880–2012	1901-1950	1951–2012	1979–2012
CRUTEM 4.1.1.0	0.086 ± 0.015	0.097 ± 0.029	0.175 ± 0.037	0.254 ± 0.050
GHCN v3.2.0	0.094 ± 0.016	0.100 ± 0.033	0.197 ± 0.031	0.273 ± 0.047
GISS	0.095 ± 0.015	0.098 ± 0.032	0.188 ± 0.032	0.267 ± 0.054
Berkeley	0.094 ± 0.013	0.111 ± 0.034	0.175 ± 0.029	0.254 ± 0.049

Source: (IPCC, 2013).

Figure (2.3) shows the annual global mean observed temperatures. The right hand axis shows the estimated actual temperature (°C) and the left hand axis shows anomalies relative to the 1961 to 1990 average; linear trend fits to the last 25 (yellow), 50 (orange), 100 (purple) and 150 years (red) are shown, and correspond to 1981 to 2005, 1956 to 2005, 1906 to 2005, and 1856 to 2005, respectively. Note that for shorter recent periods, the slope is greater, indicating accelerated warming.

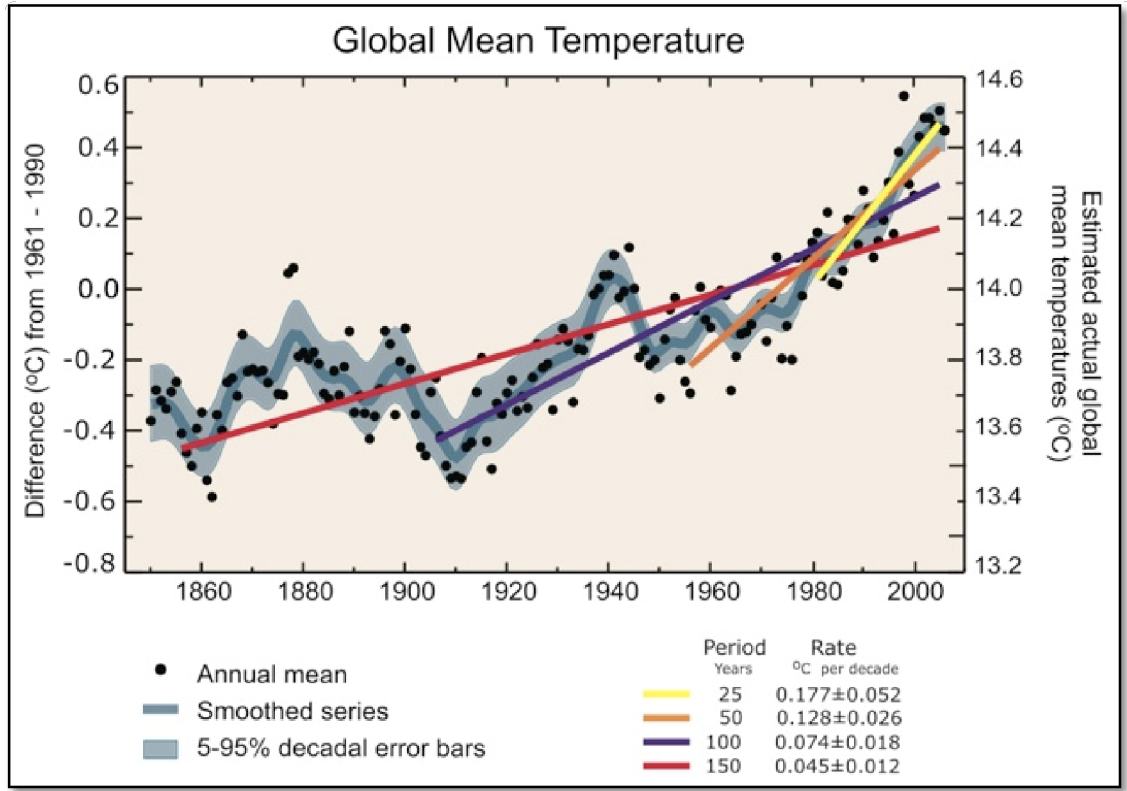


Figure (2.3): Annual global observed mean temperatures.

Source: IPCC, 2007a.

Some of the observed changes in climate extremes are shown in Figure (2.4) with the arrow direction denoting the sign of the change. The most effective global changes in climate extremes are daily temperatures including heat waves events which results from warming. Precipitation extremes also appear to be increasing. However, the existing indications show that droughts have increased in some regions (e.g., the Mediterranean) and decreased in others (e.g., central North America) since the middle of the 20th century.

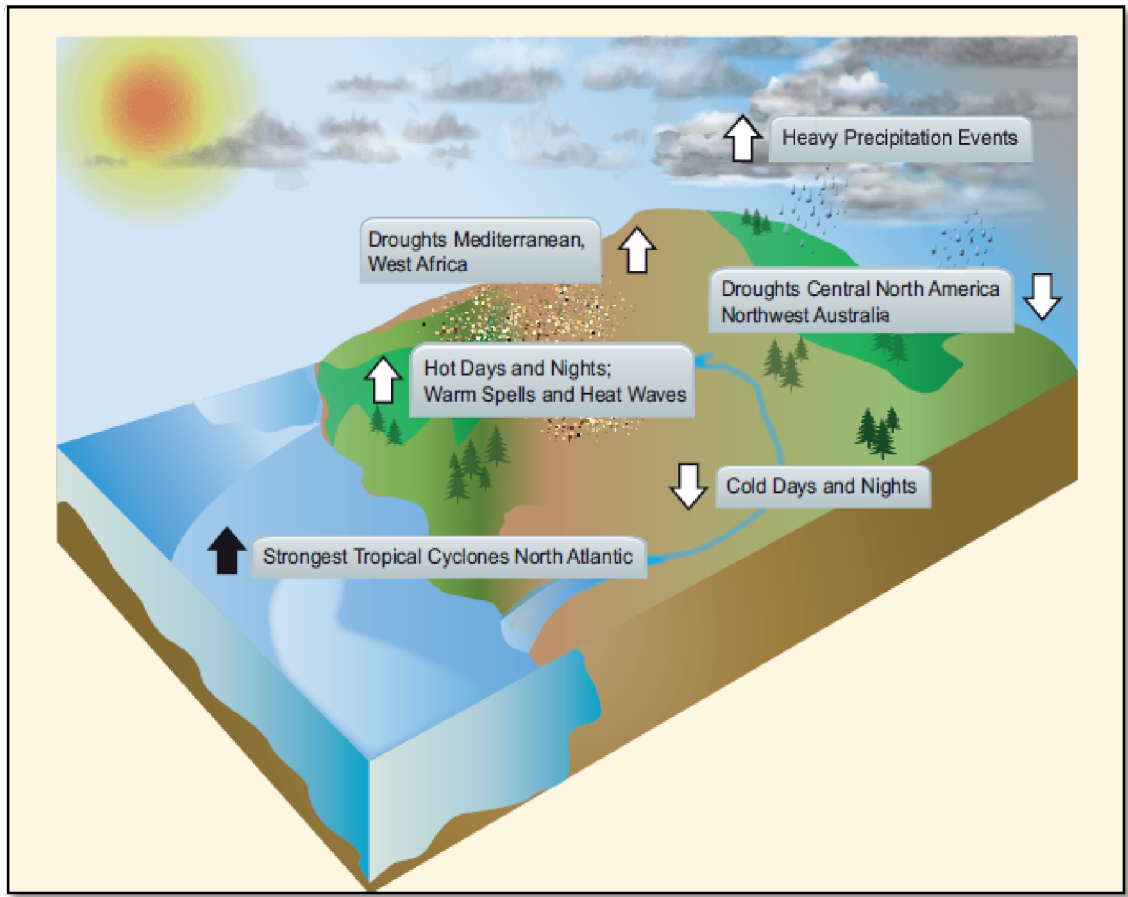


Figure (2.4): Observed trends in the intensity of various climate extremes.

Source: IPCC, 2013.

In summary, several observed trends in the independently analyzed global and regional LSAT data support that globally averaged LSAT has risen since the late 19th century and that this warming has been particularly marked since the 1970s (IPCC, 20013).

b. Precipitation:

According to Trenberth (2011), precipitation is influenced by the global warming. Moreover, heat increase causes much evaporating and that's lead to drying surfaces and finally to droughts. Hence, storms, whether individual thunderstorms, snow storms extra tropical rain, supplied with increased moisture, produce large precipitation events. Such events

raise the risk of flooding even where total precipitation is decreasing. (Trenberth, 2011).

Precipitation change trends are more partially and seasonally variable than temperature change. Global precipitation averages over land are hiding large regional variations (IPCC, 2007a).

Long-term trends in precipitation amounts from 1900 to 2005 have been observed in many large regions. Precipitation has become significantly increased in the eastern parts of North and South America, northern Europe and northern and central Asia and they became wetter, but the Sahel, the Mediterranean, southern Africa and parts of southern Asia became drier (IPCC, 2007a).

2.2.2 Observed trends in the Mediterranean and Palestine

A. Palestine location

Palestine geographic region described to be between the Mediterranean Sea and the Jordan River and various adjoining lands. Although it is a comparatively small area, the West Bank is also characterized by a wide variation in topography (Ali, 2000). Figure (2.5) shows the topography of Palestine.

Palestine is located between longitudes 34°15' and 35°40' east and between latitudes 29°30' and 33°15' north. The geographic location of Palestine affects its climate features and diversity between the southern and northern sides (Ighbareyeh, Cano-Ortiz and Cano, 2014).

Climate of Palestine described as ‘Mediterranean’, represented by a long, hot and dry summer; a short, cool and rainy winter, and a dry autumn. The temperature and the evaporation rate increase in the south and east (Haddad, 2012).

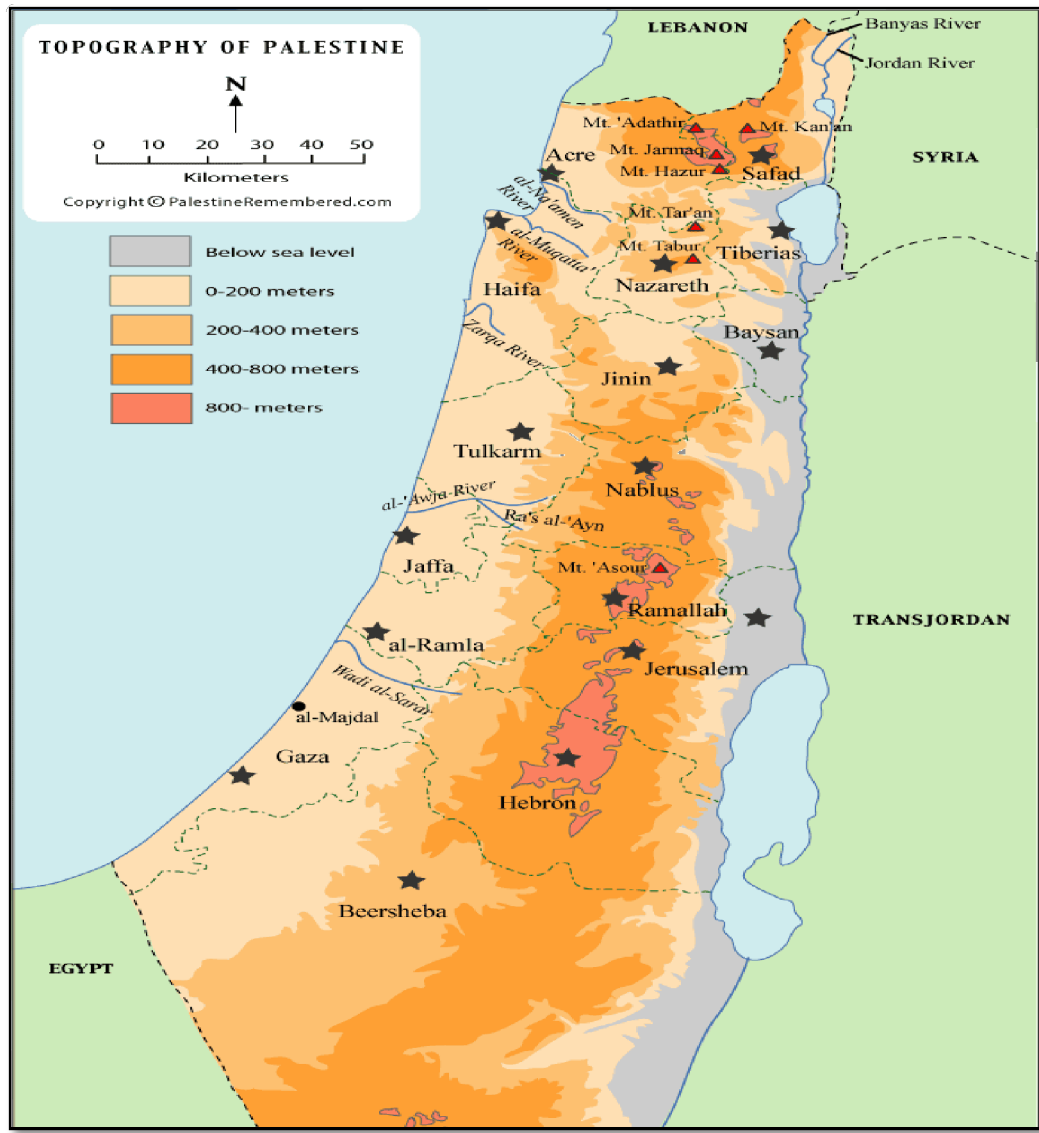


Figure (2.5): Topography of Palestine.

Source: (Ighbareyeh, Cano-Ortiz and Cano, 2014)

Palestine with its small area of about 27,000 km² is characterized by dry lands and a natural territory which is a unique episode in the (MENA) region where significant topographic and climatic variations obtain.

Palestine is known in being rich and diverse, composed of five climatic zones: the coastal zone, the semi-coastal zone, the eastern slopes zone, the central highlands zone and the Jordan Valley zone (Haddad, 2012).

B. Observed trends

Palestine climate has a great diversification, especially in the West Bank. Figure (2.6) shows climatic zones range from extremely arid to humid (Mimi et al., 2009).

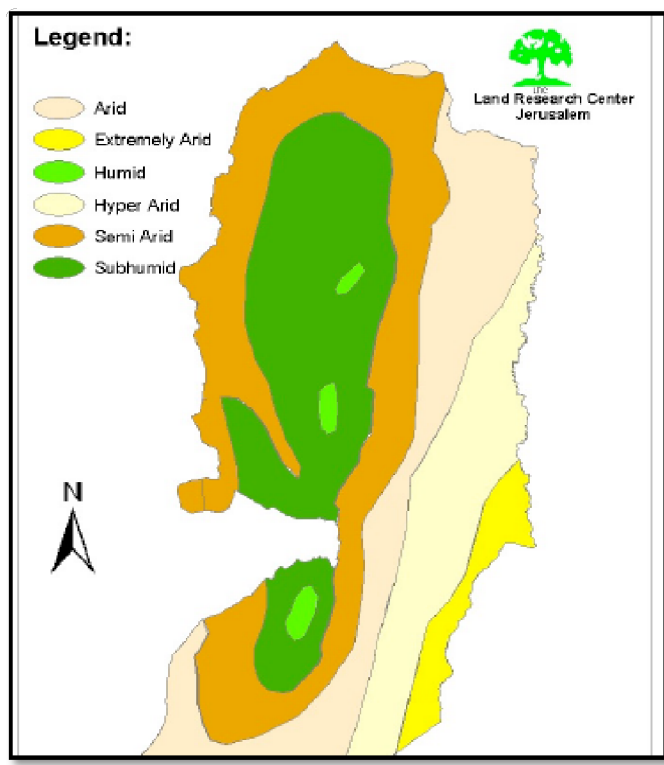


Figure (2.6): Climate classification of the West Bank.

Source: (Mimi et al., 2009)

Precipitation and temperature records for five metrological stations covering historical Palestine in the last century where studied and analyzed by Abu Sa'da (2008) as shown in Figure (2.7) and the results are shown in Table (2.2)

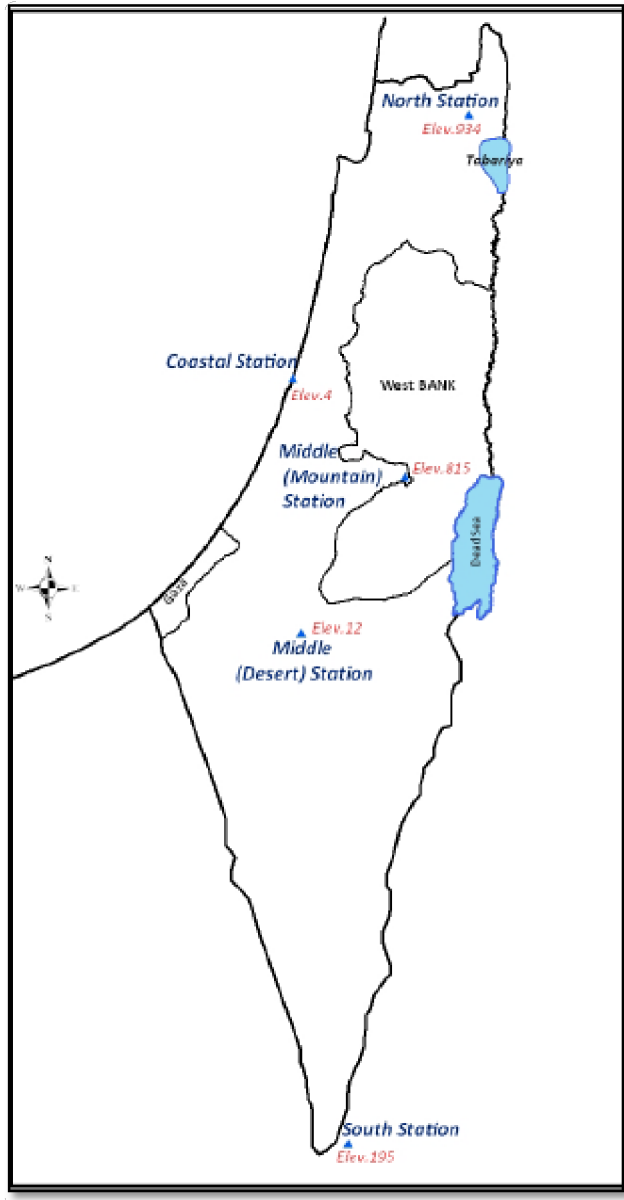


Figure (2.7): Map showing the locations of the metrological stations used in Abu Sa'da analysis.

Source: Abu Sa'da, 2008.

Table (2.2): Temperature and precipitation trend analysis for the past century.**Source: Abu Sa'da, 2008**

		Coastal station	North station	Middle station (Mountain)	Middle station (Dessert)	South station
Temperature	Period	1965-2006	1965-1999	1965-1999	1965-2006	1968-1998
	Annual mean °C	24.3	20.3	21.4	25.6	31.1
	Trend	Increasing by 9.47%	Increasing by 0.49%	Increasing by 3.27%	Increasing by 0.78%	Increasing by 0.96%
Precipitation	Period	1941-2006	1939-1999	1910-1998	1923-1998	1967-1999
	Annual mean (mm/yr)	526	702	522.7	198.5	28.8
	Trend	Decreasing by 4.26%	Decreasing by 5.5%	Decreasing by 20.28%	Decreasing by 14.11%	Decreasing by 52%

Furthermore, during the last years Palestine witnessed several climatic fluctuations (Haddad, 2012). Table (2.3) shows some extreme weather events that happened during the years between 1997 and 2004.

Table (2.3): Extreme weather events in Palestine (1997-2015)

Date	Event
18-19 March 1997 (Salem, 2011)	A heavy storm hit the central and southern parts of the West Bank, which was the second heaviest storm in March during the past 60 years.
July-August 1998 (Salem, 2011)	The hottest summer in 35 years where the temperature rose up to 46.8°C in Jericho.
Sept. - Nov. 1998 (Salem, 2011)	The driest and warmest Autumn during the past 58 years.
24 January 1999 (Salem, 2011)	A hail storm hit Jerusalem with hail stones as big as marbles (1.3 cm diameter)
28 Nov. 1999 (Salem, 2011)	Unusually cold and dry weather. The temperature in Jerusalem dropped to 6°C below zero.
July 2000 (Salem, 2011)	The hottest month of July in the 50 years, with a mean temperature of 4°C higher than average. The highest recorded temperature 41°C in Jerusalem since 1888.
February 2003 (Salem, 2011)	The wettest month since December 1991 and the wettest February ever recorded
29-30 May 2003 (Salem, 2011)	Lowest pressure ever recorded in May, accompanied by an incredible sand storm that covered Palestine and the region with thick red sand and dust
9-10 May 2004 (Salem, 2011)	Very intense heat affected Palestine, especially during the night of 9 May, when 32°C was recorded in Jerusalem. In the following nights, the temperature in Jerusalem was 20°C lower than the temperature at noon.
2013 (PCBS, 2016)	Among the ten warmest years ever recorded.
2013 (Abu As'ad, Y., Eissa, I, 2015)	Extreme snow fall up to 65 cm depth in Ramallah and 50 cm depth in Hebron (as an average), with frequent fall of snow for three times at the same year.
2014 (PCBS, 2016)	Extreme humidity ratio in Nablus 83%, the least in Jericho 43%.
2015 (Abu As'ad, Y., Eissa, I, 2015)	Repeated snow fall for two times in Ramallah, Hebron and Nablus.

Palestine with its neighboring countries of the Mediterranean region witnessed extreme weather events such as droughts especially in the southern and eastern parts of the West Bank. Such events were not frequent

in the past. An increase in rain intensity, combined with a decrease in the overall precipitation, will certainly increase the surface runoff. Thus, soil erosion and salinization income will also increase. Moreover, by the end of the last century, Palestine witnessed an increase trend in the drought to a critical value (ARIJ, 2008).

ARIJ (2011) indicated that the increase in temperature over the past 20th century in Palestine was obvious according to the Palestinian Central Bureau of Statistics. That increase was uniform during the last decade, with the year 2010 being the warmest as shown in Figure (2.8) below.

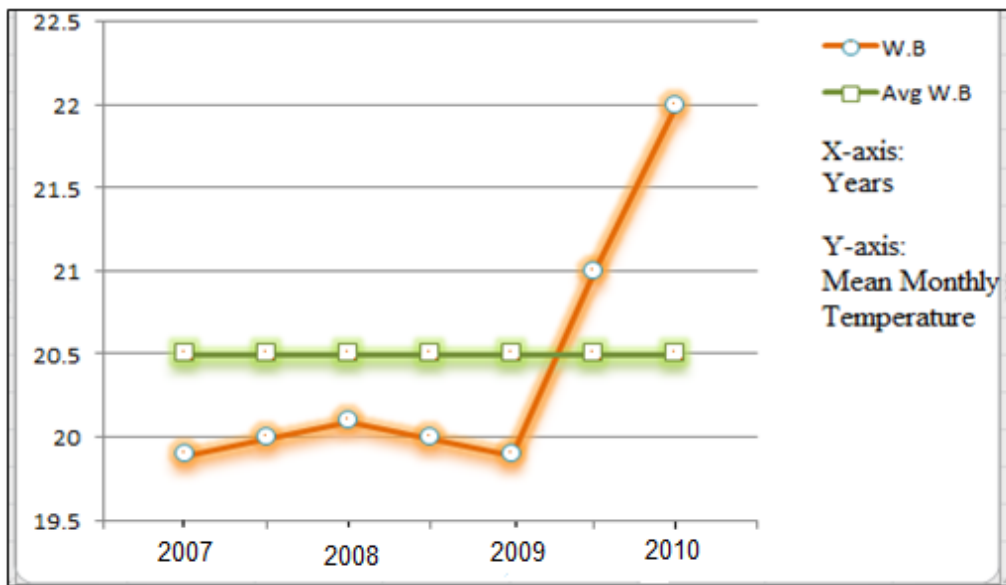


Figure (2.8): Annual mean monthly temperature (°C) in the West Bank.

Source: ARIJ, 2011.

Additionally, Palestine and Jordan have been and will be affected by climate change impacts. According to UNEP (2003), “The Middle East is a meeting point of many escalating environmental threats. This is particularly the case in Palestine. Long-term environmental degradation has occurred over recent decades. In an already densely populated area, there are

additional problems of scarcity of water resources and land, rapid population growth, a long-lasting refugee situation, climate change, desertification, and land degradation”.

Finally, since there is a few researches were conducted before on the observed trend of snow fall increase in Palestine – West Bank, this research will give insights for further researches in the future about such important topic.

2.3 Future global and regional climate change

2.3.1 IPCC fourth & fifth assessment reports

a. General

Climate projection:

“A climate projection is a climate simulation that extends into the future based on a scenario of future external forcing” (IPCC, 2013). The simulations in Figure (2.9) become climate projections for the period beyond 2005 where the results are based on the representative concentration pathways (RCP’s) scenarios.

Figure (2.9) shows the evolution of observation-based global mean temperature (T) which is the black line, the red line is the average over the ensemble of simulations, forecasts of global annual mean temperature which is plotted as thin purple lines, the ensemble mean forecast is the thick green line. The grey area is the forcing associated with volcanoes.

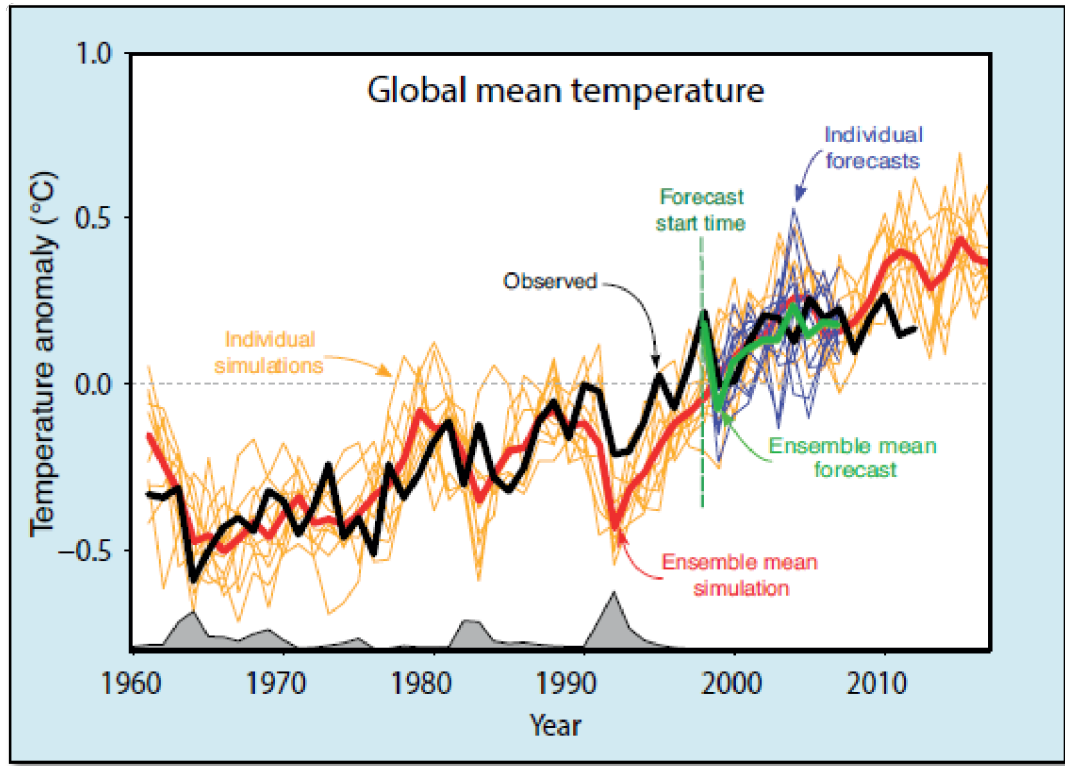


Figure (2.9): The evolution of observation-based global mean temperature.
 Source: IPCC, 2013.

Climate prediction (CP):

CP presents the future evolution of some aspect of the climate system including both forced and internally generated components. CP attempts the evolution of some climate statistic such as seasonal, annual or decadal averages or extremes. CP's are often made with models that are the same as, or similar to, those used to produce climate simulations and projections. CP proceeds by integrating the governing equations forward in time from observation-based initial conditions. CP's may also be made using statistical methods which relate current to future conditions using statistical relationships derived from past system behavior.

Figure (2.10) illustrates the progression from an initial-value based prediction at short time scales to the forced boundary-value problem of climate projection at long time scales.

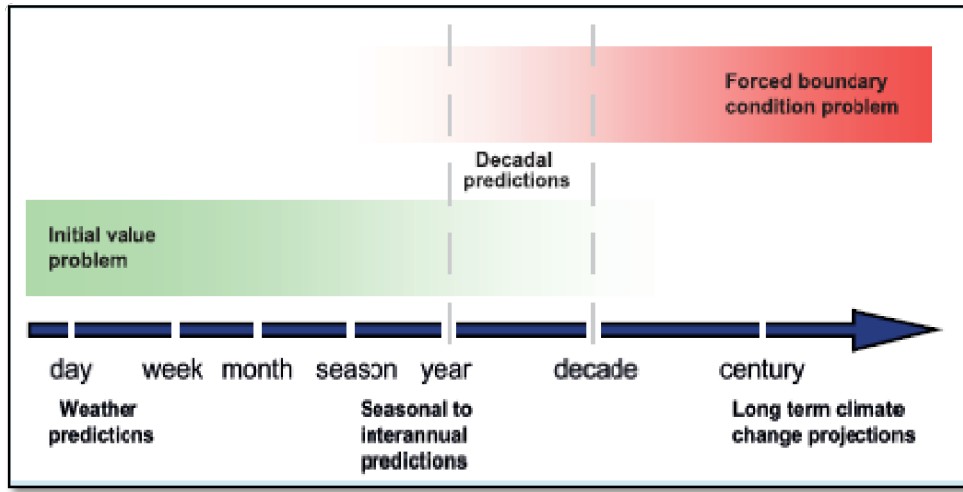


Figure (2.10): A schematic illustrating the CP progression.

Source: IPCC, 2013

IPCC fifth assessment report (AR5) considers new evidence of climate change based on many scientific analyses from observations of the climate system, climate archives, theoretical studies of climate processes and simulations using climate models. It builds upon IPCC Fourth assessment report (AR4) and consolidates subsequent new findings of research. The fourth report has described several issues about CC and finally estimates the projected future CC. Also, it has incorporated new findings from the past years of research and analysis, based on the Third Assessment Report (TAR).

Extreme events such as the extended greenhouse gas emissions above the current rates will increase global warming and lead to many

changes in the global climate system during the 21st century that would be larger than which recognized during the 20th century (IPCC, 2007b).

b. Temperature

Almost everywhere, the heat waves will be acute, more frequent and longer lasting in a future warmer climate. Reductions in cold events are projected significantly in a future warmer climate (IPCC, 2007b).

IPCC climate change projections are based on new set of scenarios which was used for the new climate model simulations. In all scenarios, the atmospheric CO₂ concentrations are higher in 2100 as a result of cumulative emissions increasing of CO₂ to the atmosphere during the 21st century and that will cause further warming and changes in all components of the climate system (IPCC, 2013).

Global mean surface air temperature (SAT) continuing to increase over the 21st century, driven mainly by increases in the greenhouse gas concentrations, the results from IPCC (Special Report on Emissions Scenarios). Scenarios are shown in Table (2.4) which obtained from different scenarios for four time periods.

Table (2.4): Annual mean surface air temperature change.

Global mean warming (°C)				
	2011-2030	2046-2065	2080-2090	2180-2199
A2	0.64	1.65	3.13	
A1B	0.69	1.75	2.65	3.36
B1	0.66	1.29	1.79	2.10

Source: IPCC, 2007b.

Where A2 scenarios are of a more divided world. The A2 family of scenarios is characterized by:

- * Continuously increasing population.
- * Regionally oriented economic development.
- * Slower and more fragmented technological changes and improvements to per capita income.

B1 scenarios are of a world more integrated and more ecologically friendly. The B1 scenarios are characterized by:

- * Rapid economic growth with rapid changes towards a service and information economy.
- * Population rising to 9 billion in 2050 and then declining.
- * An emphasis on global solutions to economic, social and environmental stability.

Finally, based on the technological emphasis; A1B is a balanced emphasis on all energy sources.

In addition, the global mean surface temperature change for the period 2016–2035 relative to 1986–2005 will be in the range of 0.3°C to 0.7°C. Relative to the average from year 1850 to 1900, global surface temperature change by the end of the 21st century and projected to exceed 1.5°C for some scenarios and 2°C for others (IPCC, 2013).

c. Precipitation

IPCC projections of 21st century showed that the global mean precipitation increases with global warming of over 20% in limited areas such as east Africa, central Asia and the equatorial Pacific Ocean. Substantial reduction reaching to 20% occurs in the Mediterranean region, Southern South America, the Caribbean region and the subtropical western coasts (IPCC, 2007b).

IPCC highlighted that there is uncertainty in projected changes in rainfall. Precipitation changes may arise as a consequence of temperature and stratification changes but the basic pattern of wet regions tending to get wetter and dry regions tending to get dryer is apparent for the period 2016–2035 relative to 1986–2005 (IPCC, 2013).

2.3.2 Predictions for Mediterranean

a. General predictions

IPCC Fourth Assessment Report predicts that, for the southern and eastern Mediterranean, warming over the 21st century will be larger to be between 2.2 and 5.1°C. Annual precipitation is very likely to decrease in the area up to 10% by 2020 and 20% by 2050 with an increased risk of summer droughts (IPCC, 2007d).

Several researches indicate substantial climate changes, (Lelieveld et al., 2012) pointing to a continual and gradual future warming in the Eastern Mediterranean and the Middle East (EMME), being strongest in the north.

In comparison with the reference period (1961–1990) the mean temperature will be about 1–3°C in the near-future (2010–2039), 3–5°C by mid-century (2040–2069) and 3.5–7°C by the end-of-century (2070–2099). The mean temperature trend over the period 1950–2100, with a focus on capital cities in the EMME, is about (0.37 ± 0.9) °C/decade. This suggests that the region warms much more strongly than other regions.

Furthermore, the modeled changes in precipitation show large variability in space and time in winter, the strongest drying is projected around the eastern Mediterranean. In summer, the EMME drying is particularly large during 2040–2069 compared to the end of the century. In the northern EMME, mainly in Turkey, Cyprus, Lebanon and Palestine, the number of rainy days may decrease by 5–15 days at mid-century and by 10–20 days per year at the end-of-century (Lelieveld et al., 2012).

UNDP (2010) predictions pronounced an increasing warming events for the eastern Mediterranean by the end of the century, temperatures rises up in ranges of 2.6 to 3.5°C even to 4°C for some regions with warming stronger in summer than in winter. Current forecasts from climate models exhibit decreasing winter precipitation by 2100 of up to 35% compared to late twentieth century timelines.

According to UNDP (2010) predictions, points mentioned below illustrate some of the forecasted environmental effects of climate change on the Middle East, many of these impacts have been happened and they are predicted to increase in the future:

Effects on water:

- * Increased storm water flooding and insufficient rain to recharge aquifers.
- * Reduced surface and groundwater quality.
- * Increased water shortages from lower rainfall and higher evaporation.

Agriculture:

- * Changes in economic viability of crops and higher food prices.
- * More frequent droughts and increased desertification.
- * Increased crop water requirements.
- * Decline in grazing ranges and stocks.

Energy:

- * Increased energy and fuel demands to cope with more temperature extremes.
- * Rising fuel demands to cope with water shortages.

Public health:

- * Increase in public health ailments related to the lack of water.
- * Increased heat stress from high temperature extreme events.
- * Spatial and temporal alteration of disease vectors.

b. Palestinian predictions

It was found that a decrease in precipitation is likely to occur according to climate models around the (30° North) latitude belt, and since Palestine lies around this belt, the consequence of any such projection may be hazardous for the status of its ecosystem (ARIJ, 2008).

Regional climate change implications for Palestine over the next 50 years are expected to consist of (ARIJ, 2011):

- * A decrease in annual average precipitation
- * An increase incidence of drought
- * An increase in extreme climatic events.

A number of key areas are negatively affecting human and economic development in Palestine such as water resources, agriculture and food security, public health, and tragedy risk reduction (ARIJ, 2011).

c. Israeli predictions

The following climate scenarios are projected for Israel by the year 2100 as stated in the first report of Israel to the Conference of the Parties of the United Nations Framework Convention on Climate Change (Pe'er and Safriel, 2000):

- * Mean temperature increase of between 1.6 to 1.8 °C.
- * Reduction in precipitation by (8) % to (4) %; increased rain intensity; and changes in rainfall patterns.

- * Increase in evapotranspiration by 10%.
- * Delayed winter rains.
- * Increased rain intensity and shortened rainy season.
- * Greater seasonal temperature variability.
- * Increased frequency and severity of extreme climate events, such as droughts and floods.
- * Greater spatial and temporal climatic uncertainty.
- * Some models predict as much as a 50 percent reduction in mean annual precipitation in the Jordan River Basin.

To conclude, different analysis proved that the climate is changing over time. In Palestine, temperature is increasing and rainfall is decreasing. In addition to several other changes such as the recent snow fall and wind events which are still under research.

The increased temperature and decreased rainfall confirms the IPCC observations and predictions, projections show that the intensity of these changes will intensify within this century and so a response to these changes is a major urgency due to CC adverse impacts over the whole country. Decision makers within the Palestinian national authority and civil society organizations should formulate policies and develop response mechanism that effectively addresses climate change (ARIJ, 2012).

This is the end of the evaluation of the observed climate change and predicted trends category and the subjective aspects of its expected risk is viewed in the subsequent category; climate change risk.

2.4 Climate change risk

“We are living in a risky world, and it is getting riskier and riskier” (Wu, 2011). To name a few risk issues: construction risk management, market risk, energy risk assessment, environmental risk analysis, risk management and sustainable development.

Only a decade ago, climate change has been categorized as one of several threats to biodiversity. Scientists and specialists are pointing to climate change as one of the vast challenges of the twenty-first century (Hilty et al., 2012).

The most important challenge of this century is the battle against management of climate change. It is important to understand the intensity and severity of its long-term threats before we turn to the shorter term. To respond to such incidents, instant and firm actions should be done immediately (Stern, 2009).

Climate extremes which are leading to natural tribulations have been observed recently. From around 200 a year to over 400, the number of recorded natural disasters has more than doubled in number. Nine out of every ten of these disasters are now climate-related, with increasingly significant outcomes through societies, economies and natural ecosystems.

As we mentioned before, IPCC has identified the extreme events, or disasters, with the possibility to be changed by climate change (Hay and Mimura, 2010).

In the past 30 years, new risks are being identified. Moreover, it is not just the nature of major risks change, but also the state within which they appear. In particular risks such as health, transport, environment, telecommunications risks are becoming more difficult to manage. In response to these challenges many countries have informed different hazard tools to address the extreme phenomena (Lin et al., 2015).

Climate change could influence several parts of social, political and economic aspects and cause problems. Moreover, it could act as a “threat multiplier” by increasing conflict and variation in several regions, so it should be identified and studied carefully in order to give a roadmap for future researches to better understand its instability and vulnerability. Developing countries to be ready to respond the expected negative effects deserve special attention (Brauch et al., 2011).

There is now broad recognition for the need of disaster risk management that dealing with climate change event. There is also an increasing awareness of the emergency for a multi sectorial approach in managing the effects of climate variability and climate change, since this can lead to a considerable reduction of risk and better integration of climate change mitigation and adaptation considerations (Leal Filho, 2013).

The aim of climate research is to increase the knowledge about the nature of climate and the causes of its change. Also, to increase our understanding of the physical processes on various places in order to reduce uncertainty and improve our capabilities to predict climate on monthly or seasonal and long term timescales (Wanner et al., 2006).

Finally, the growing danger of climate change calls for an increased global studying and understanding. Such understanding is very necessary to act on the risks that climate change presents for the achievement of reducing the consequences of extreme weather. Climate events present a major challenge and the required responses may involve difficult actions. Reducing the consequences of disasters requires governments, private sector and communities to work together. The occurrence of weather and climate-related hazards which typically result in disasters is beyond human control. Additionally, the increase in frequency and intensity of extreme events are something we must learn to adapt and live with (Hay and Mimura, 2010).

2.5 Introduction to risk assessment

2.5.1 Risk definition

Risk and risk assessment concepts have a long history. More than 2400 years ago people used to submit their ability of assessing risk before making decisions. Risk assessment and risk management as a scientific field is young, not more than 30 to 40 years old. However, the field has

developed frequently, advanced analysis methods and techniques have been developed for how to conceptualize, manage and assess risk. Risk analytical approaches and methods are now used in several sectors (Aven, 2016).

If ten people were asked about risk definition, ten different answers will be identified for it. According to Rausand (2011); “Risk is related to what can happen in the future”. In some of the statement, risk can be replaced by chance, probability or likelihood and it can be synonymous with hazard, threat or danger.

Risk concept is highly polysemous and includes large number of definitions (Rodney et al., 2015). In agreement with ISO 31000 which is the reference for risk management; it was defined as the “effect of uncertainty on objectives” (ISO 31000, 2009). The uncertainty known as not knowing what will happen in the future. The greater the uncertainty, the greater the risk (Crane et al., 2013).

It can also be defined as “*the chance of injury or loss or the measure of the probability and severity of an adverse effect to health, property, the environment, or other things of value*” (NSC, 2002).

Risk is unavoidable, and every organization needs to know what risks it faces in order to evaluate them also to take action to manage risk in a way which it can justify to a level to be tolerable. The orange book (2004) has defined the risk as “*uncertainty of outcome, whether positive*

opportunity or negative threat, of actions and events. It is the combination of likelihood and impact, including perceived importance”.

Risk is usually consist of the severity of an event combined with the probability or likelihood of that event occurring. Combining the severity of all loss events associated with a system with their estimated future probability or likelihood provides a metric for risk of loss associated with the system itself. This definition is widely used and accepted. Determining severity, or worst case losses, is usually not difficult. The problems arise in estimating the likelihood of events in the future. If the system design and use in the future are very similar to those in the past and adequate historical data is available, estimating probability is not subject to much controversy but if new designs or new technology is involved or usage may differ from the past, likelihood estimates are more difficult to establish (Leveson, 2015).

A risk is a loss and something that is wanted to be minimized; it can delay or even stop the work. Risk consist of direct and indirect risks, indirect risks are those not directly related to the project, for instance, external risks which are very difficult or even impossible to manage, such as the environmental risks. There are many factors affecting every project, such as weather, inflation, political decisions and transportation. Naturally, the risk lies in how to manage these uncertain events (Munier, 2014).

Indeed, the term “Risk” contains several activity levels which should support each other (Blair, 2002). Also, there are tools for managing risks,

but they do not represent the project or its environment, and thus address independently the risks. On the other hand, traditional risk management tools do not illustrate the full meaning of risk concept; therefore, some tools for integrated management of risk concept have been developed.

2.5.2 Risk analysis

“Risk” is related to what can happen in the future; it can be analyzed and managed in rational ways, the first tool is “risk analysis” which can be defined as: “Systematic use of available information to identify hazards and to estimate the risk to individuals, property, and the environment.” Risk analysis is very important to identify the causes of any harm events such as events caused by natural forces, to evaluate the possible consequences of the harmful events, to identify barriers, and finally to decide if the risk related to a system is tolerable (Rausand, 2011).

Risk analysis (RA) is an efficient way to predict and reduce the risk of occurrence of an accident in any system. RA techniques share a common objective, which is to provide an assurance that a process or a system is designed and operated under an “acceptable risk” (Ferdous et al., 2012).

Risk analysis is performed in order to give answers to the following three important questions (Munier, 2014):

1. What can happen?

The possible hazardous events that may affect some assets such as people, environment and etc. should be known in order to answer this question.

2. What is the probability of its occurrence?

This question could be answered as a qualitative statement or as probabilities or frequencies. Here, we determine the likelihood of the hazardous events that were identified in Q.1 by carrying out a causal analysis to clarify the basic causes of hazards or threats that may lead to the hazardous event.

3. If the event, indeed, does happen, what are the consequences?

For each hazardous event, the potential harm or consequence should be identified. The harm could be managed or prevented by adding barriers to the system. Finally, by answering these three questions, risk will be clearly identified.

Risk assessment and risk management are two parts of the risk analysis process. Risk analysis (RA) involves developing an understanding of the risk, it provides an input to risk evaluation and to decisions on whether risks need to be treated. The Environmental Risk Analysis (ERA) deals mainly with the evaluation of uncertainties in order to ensure reliability in a broad range of environmental issues, including utilization of natural resources. ERA is a general framework providing tools and methods for problem formulation, exposure and response characterization also risk quantification (Morel and Linkov, 2006).

The selection of suitable risk analysis technique is critical to the entire risk management process. Risk analysis techniques can be subsumed

into two main categories, namely qualitative and quantitative techniques. The qualitative risk analysis technique does not operate on numerical data, presenting results in the form of descriptions, recommendations and ordinal scores. The categories of RA techniques can be plotted according to their degree of analytic assessment of risk exposure (De Marco et al., 2012). The main qualitative analysis techniques are listed in table (2.5).

Table (2.5): List of Qualitative risk analysis techniques.

Technique	Definition
Brainstorming	Best possible solutions about project risk are generated under the leadership of a facilitator.
Cause and effect diagram	It is also known as Ishikawa or fishbone diagram. It is useful for identifying causes of risks.
Checklists	It is a detailed aide-memoire for the identification of potential risks based on past similar projects.
Event tree analysis (ETA)	It models the range of possible outcomes of one or a category of initiating events. It usually provides qualitative descriptions.
Risk breakdown matrix	It is an “activities and threats” matrix, the risk number for each activity and the most frequent overall risks are evaluated.
Risk data quality assessment	It evaluates the extent to which risk is understood and the accuracy, quality, reliability, and integrity of risk data.

Source: (De Marco et al., 2012).

With quantitative analysis techniques, the estimation of risk exposure is connected with application of numerical measures. Quantitative techniques numerically analyze the effect of identified risks on the project objectives. The main quantitative techniques are listed in table (2.6).

Table (2.6): List of Quantitative risk analysis techniques.

Technique	Definition
ABC classification or Pareto analysis	It is an analysis of levels of risk significance. Risky events are grouped into three categories (A, B, C) in order of their estimated importance, with 'A' being very critical.
Decision tree analysis	It is a decision flow diagram, subject to the influence of future events whose probability of occurrence is known.
Expected monetary value	Takes into consideration the probability aspect of the system states and is based on a gain matrix.
Expert judgment	It is based on the expert opinions for the evaluation of failure rate and success chances of the overall project.
Fault tree analysis	Possible derivative risk events are derived from a top event.
Probability distributions	Continuous probability distributions represent the uncertainty in values, such as durations of schedule activities and costs of project.

Source: (De Marco et al., 2012).

2.5.2.1 Hazard identification

To deal with the first question: What can happen?, all the dangers and hazards that may cause harm to assets should be identified, environment, people or other types, there are several methods developed in order to facilitate dealing with this question and known as *hazard identification methods* (Rausand, 2011).

Hazard identification (HI) is the process of finding, recognizing and describing risks (ISO 31000, 2009). Identifying the risk is the first step in managing risk process which is about classifying the prospective risks (Crane et al., 2013).

2.5.2.2 Causal and frequency analysis

To deal with the second question: What is the probability of its occurrence and how will the hazardous event occur?, it is important to analyze and identify the possible cause of the hazardous event and that is known as the causal analysis. Fault tree (FT) analysis is an efficient method of the causal analyses of hazardous events, it is the most commonly used method and suitable for quantitative and qualitative analysis of systems, it is applied in accident risk assessment to identify and analyze risk causes, as well as estimate the probability and corresponding consequence of each risk (Wu and Zhang, 2014), this method will be used during the research in the analysis step.

2.5.2.3 Accident Scenarios analysis

To deal with the third question: If the event does happen, what are the consequences and how can the possible consequences of a hazardous event be determined?, it can be accomplished by determining the possible event sequences that can possibly happen after hazardous event occurrence. Event tree (ET) analysis will be implemented in this research and it is known as the most commonly used method for the development of sequences scenario, it is also identifying and analyzing the barriers that are provided to prevent, control or mitigate the harmful effect after the sequence scenario (Rausand, 2011).

Additionally, in this research, bow tie analysis and risk matrices will be used also due to their importance and clearness as an overall risk

analysis. First, the “Risk Matrices” are widely used tools for analyzing, visualizing and assessing risk in different systems. The main benefits attributed to risk matrices are their simplicity: they are recognized to be easy to construct, explain and score (Goerlandt and Reniers, 2015). It is also presenting the qualitative or quantitative risk analysis with columns corresponding to various levels of consequence and rows to different levels of likelihood. It has been used to characterize the risk levels of any system accidents (Wu and Zhang, 2014).

Secondly, the bow-tie model (BT), it is very prevalent assessment method because it represent the accident scenario altogether including causes and consequences (Khakzad, Khan and Amyotte, 2012). Bow tie diagram is also a popular method to implement safety barriers. It defines several protective and preventive barriers to reduce the severity of a given risk (Badreddine et al., 2014). Controlling risk by different barriers is very important in all workplaces, particularly in “sensitive” or high-risk systems (Kouabenan, Ngueutsa and Mbaye, 2015). Finally it is an effective method in connecting between FT and ET (Ferdous et al., 2012).

Figure (2.11) shows a typical Bow tie diagram that links the hazards and the consequences through a series of event lines, also it includes the barriers that are planned or implemented to be connected to the event lines to which they are relevant, barriers are very important to control and manage these events (Rausand, 2011).

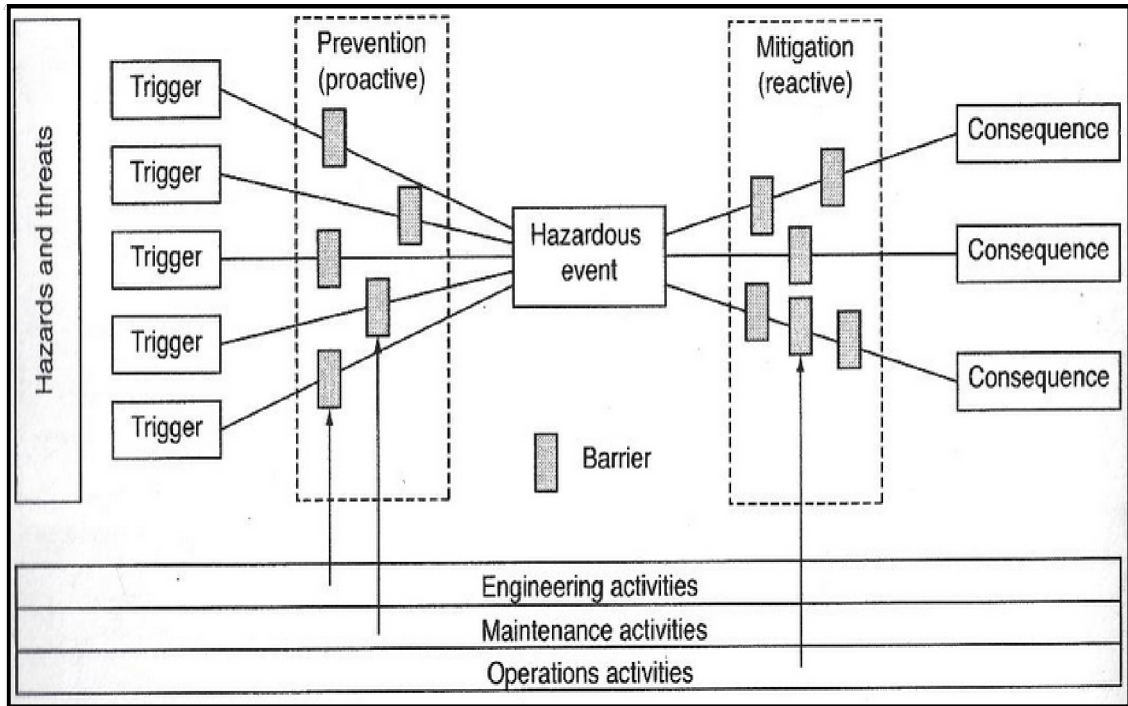


Figure (2.11): Bow-tie diagram

Source: (Rausand, 2011)

2.5.3 Risk evaluation

Risk evaluation is different from risk analysis, it could be defined as: “Process of comparing the results of risk analysis with risk criteria to determine whether the risk and its magnitude are acceptable or tolerable”. Moreover, risk analysis should be involved in the evaluation (ISO 31000, 2009).

The purpose of risk evaluation is to help taking decisions, based on the outcomes of risk analysis, about which risks need treatment and the priority for treatment implementation. Risk evaluation involves comparing the level of risk found during the analysis process with risk criteria context reference. In some situations, the risk evaluation can lead to a decision to undertake further analysis. The risk evaluation can also lead to a decision

not to treat the risk in any way other than maintaining existing controls (Munier, 2014).

In order to formulate a response to climate change, it is necessary to make risk evaluation of the past and expected impacts (Cook et al. 2013).

2.5.4 Risk assessment

a) Introduction

Once threats are identified, they must be assessed (Munier, 2014). Risk assessment could be done after carrying out the risk analysis and evaluation in one joint process. It is defined as the overall process of risk identification, risk analysis and risk evaluation (ISO 31000, 2009).

The new trends in systems improvement should be now directed toward the minimizing and elimination of the potential integrated threats of the events by applying different methods of risk assessment especially in the context of environmental management (Karkoszka, 2015).

Environmental Risk Assessment (ERA) is a process that evaluates risks to environment caused by human activities or natural disasters, it also assesses the appropriate level of precaution and interrelated risk management measures to reduce and mitigate hazards, and their adverse impacts so as to achieve an acceptable risk level. ERA as an important component and useful technical method of Environmental Impact Assessment (EIA) helps to evaluate, prevent and alleviate extremely adverse environmental impacts (Wu and Zhang, 2014).

Most of the projects subjected to environmental impact assessment are closely related to climate change, as they contribute to, or are affected by it. The growing certainty on climate change and its impacts make it an essential part of the EIA process (Salamanca, Aranda and Sierra, 2016).

b) Risk assessment steps

To implement a successful risk assessment, five steps should be performed (Rausand, 2011):

- * Identify the hazard.
- * Decide who could be harmed and how.
- * Evaluate the risks.
- * Record your findings and implement them.
- * Review and update the assessment.

2.5.5 Risk management

Risk assessment and risk management are similar but with different processes, risk management decision nature is often influencing the scope and depth of a risk assessment. Risk assessors usually ask “How risky is this situation?” and risk managers then ask “What are we willing to accept?” and “What shall we do about it?” (Leeuwen, 2007).

Risk management has become an increasingly challenging activity (Azevedo, Ensslin and Jungles, 2014). It has been developed rapidly in recent years and this development is international.

There are several definitions of risk management. For example, Beer and Foran (2000) identified risk management as a formalized method of dealing with uncertainty, while (Berg, 2010) viewed risk management as an integration of the process of risk, risk assessment, strategies and risk management mitigation. Objective of risk management is to reduce different risks related to a pre-selected domain to an acceptable limit. It may refer to numerous types of threats caused by environment, technology, humans, organizations and politics (Berg, 2010). Risk assessment involves risk identification, risk analysis and risk prioritization while risk control involves risk planning, risk mitigation, and risk monitoring (Williams, 2011).

Risk management is a continuous management process that includes six elements as illustrated in Figure (2.12). These elements are: **identify** (continually ask, what could go wrong?), **analyze** (continually ask, which risks are most critical to mitigate?), **plan** (develop mitigation approaches for the most critical risks), **track** (track the mitigation plan and the risk), **control** (make decision based on data) and **communicate** (ensure a free-flow of information throughout the process) (Leschka and Packard, 2012).

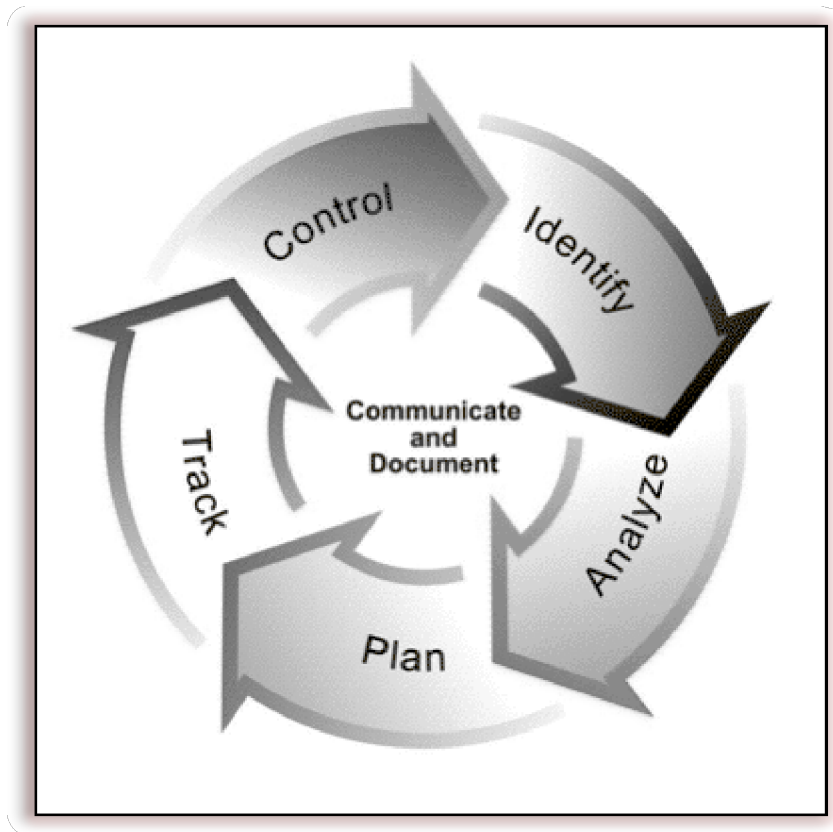


Figure (2.12): Continuous risk management process.

Source: (Leschka and Packard, 2012).

Finally, there is urgent need for the risk management strategies in order to enable agencies to successfully achieve their goals. On the other hand the general benefits of corporate risk management can be explained as a reduction of the different risks threatening any system (Müller, Wittmer and Drax, 2014).

To conclude, Figure (2.13) below summarize the overall risk process which contains risk analysis, evaluation, assessment, control and risk management (Rausand, 2011).

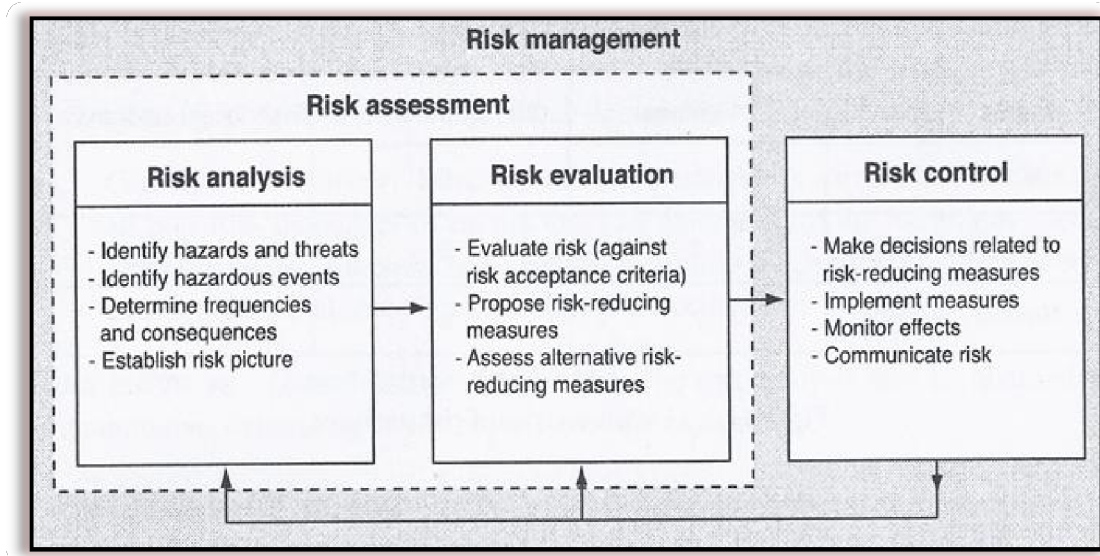


Figure (2.13): Risk analysis, evaluation, control, assessment and management.
Source: (Rausand, 2011).

This is the end of risk assessment process category and the subjective aspects of how to assess risks in constructions and how could constructions be affected by the extreme events that resulted from climate change is viewed in the subsequent category; risk in constructions.

2.5.6 Risk in constructions

“Risk is an inherent property of every project” (Rodney et al., 2015).

No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be “ignored”. Furthermore, constructions may face different uncertain conditions based on its type, resources, goals and priorities (Latham, 1994).

Over the past years, firms are faced with more risk and uncertainty than before. Risk management has become an important part of the management process for any project. Risk in construction has been the

object of attention because of time, cost and quality of the construction projects. The need to manage risks in construction is relevant to all professionals and groups (design team, project management team, client groups, contractors, etc.) in the construction industry (Akintoye and MacLeod, 1997). Designers, clients and government should work together to minimize construction risks and carry out safe, efficient and quality construction activities. Constructions may face different kinds of risks such as risk related to designers or to contractors, government and external risks (Zou et al., 2007).

There are different risks sources that may affect the construction activities such as physical, environmental, design, logistics, financial, legal, political, construction and operation risks. It is important to take management contingency and technical contingency into account while achieving any project objectives (Akintoye and MacLeod, 1997).

Furthermore, many engineers, owners and contractors are unaware of the full range of these risks, and few have demonstrated the expertise and knowledge to manage them effectively. However, in construction environment there is a gap between the existing risk management techniques and their application and use by specialists and owners and that is due to the complexity of the situation or resources commitment to perform good risk management as well as that there is no easy-to-use management tool available that can identify and assess the risks specific to construction conditions (Rawash et al., 2014).

Managing risks in construction projects has been recognized as a very important process in order to achieve project objectives in terms of time, cost, quality, safety and environmental sustainability. While risks cannot be eliminated, successful projects are those where risks are effectively managed, of which early and effective identification and assessment of risks is essential. Risk management process builds an understanding of what might put goals in jeopardy and what should be done to ensure success (Zou, et al., 2007).

It is clear that projects which used to structure risk assessment process will have a better chance of meeting financial, schedule, and other expectations (Rawash et al., 2014).

The aim of this research is to focus on the environmental source that could have effects on the constructions activities and occur risk. Snow effect will be taken as a case study in order to reduce its impact over steel structures specifically.

2.5.7 Effect of CC on constructions in the WB

a. Introduction

The construction sector is one of the key economic sectors and is the main motivation in the Palestinian national economy. The construction sector has witnessed a noticeable expansion and activities. Therefore, the construction sector has occupied the foremost position among the rest of

sectors, mainly in the attraction of investments and creation of new jobs (PCU, 2003a).

Constructions in Palestine is categorized into four main types, every single type could face different risks; those types are (Saqfelhait, 2012):

- * Residential Housing Construction.
- * Specialized Industrial Construction.
- * Infrastructure and Heavy Construction.
- * Institutional and Commercial Building Construction.

Different threats may affect firms, constructions and various activities with a certain probability of occurrence and provoking different kinds of damages or impacts at different levels of severity; therefore, we have probabilities and impacts of which has been defined as risk. Threats may affect assets, and thus, it is convenient to learn how to manage these threats (Munier, 2014).

Disaster from nature could be defined as a serious error of the functioning of a society or economy due to the occurrence of an infrequent or abnormal hazard which causes losses that exceed the ability of the affected people to deal with. Losses due to natural disasters seem to display an upward trend, both in economic and human terms (Hochrainer, 2006).

In the recent years, natural climate changes affected the constructions in Palestine and causing different losses and damages. Snow

effect was clearly viewed. The country was not prepared to deal with the extreme snow loads; therefore factories owners and residents encounter different problems.

b. Snow risk in Palestine

Specialists have continuously asked for better methods and resources to help them assess their risks related to climate variability and extremes (Svoboda et al., 2015).

Snow is one of the risks that we may face in Palestine, and the need for better snow risk methods and tools has also been required. Snow is a natural event that affects every location around the world. Understanding how snow fall develop, evolve, and impact us is vital to knowing how to better prepare and plan for them and mitigate their impacts in order to reduce snow risk in the future.

In the past few years, constructions witnessed several damages caused by different causes such as the instability of the structure, the structures have been not designed or because of the unexpected and accumulated fall of snow which lead to different problems. Other information and analysis about the causes of structure failure are discussed in the risk analysis (section 4.3).

Constructions confront high loads of snow that they were not used to take before and cause several damages. Figures below (2.14), (2.15) and (2.16) show an increasing snow fall trend in the West Bank in (Ramallah,

Hebron and Nablus). Slope is clearly gives an increasing sign of snow fall trend (PMS, 2015).

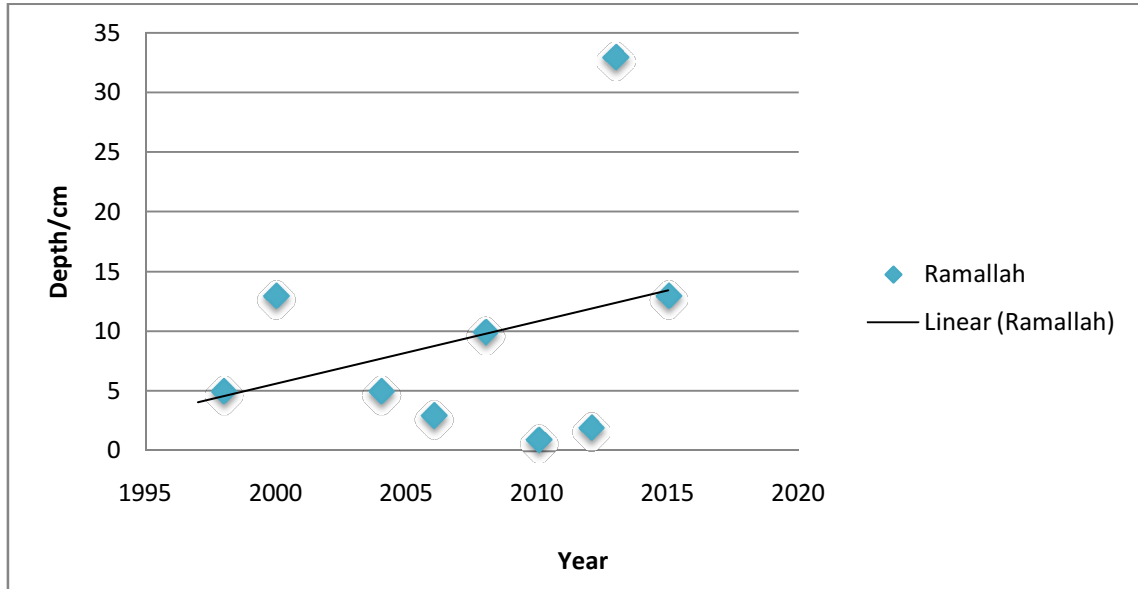


Figure (2.14): Increasing trend of snow fall in Ramallah (1997 – 2015).

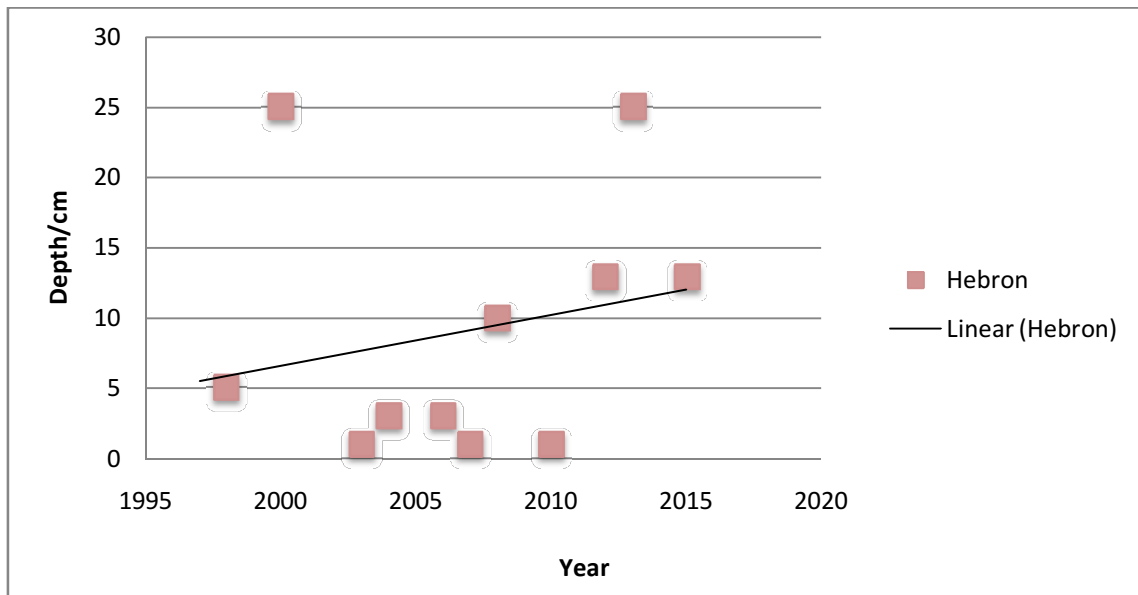


Figure (2.15): Increasing trend of snow fall in Hebron from (1997 – 2015).

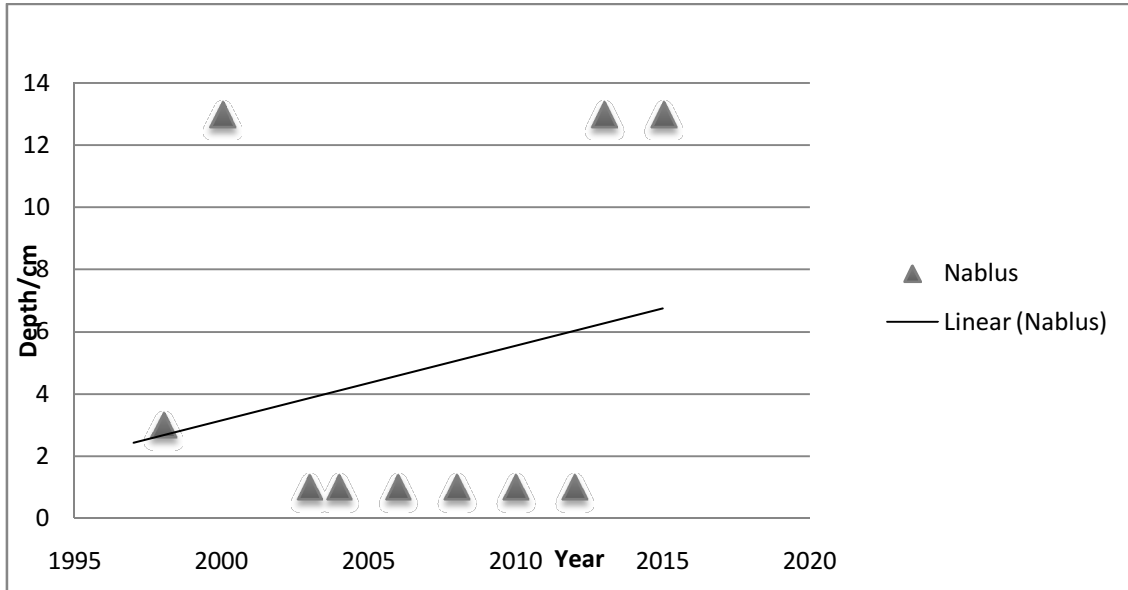


Figure (2.16): Increasing trend of snow fall in Nablus from (1997 – 2015).

Figure (2.17) below shows an increase trend of snow fall in Jerusalem for the years (1921-2015) (02ws.co.il, 2016). More information about the data related to the Figures is shown in Annex (A).

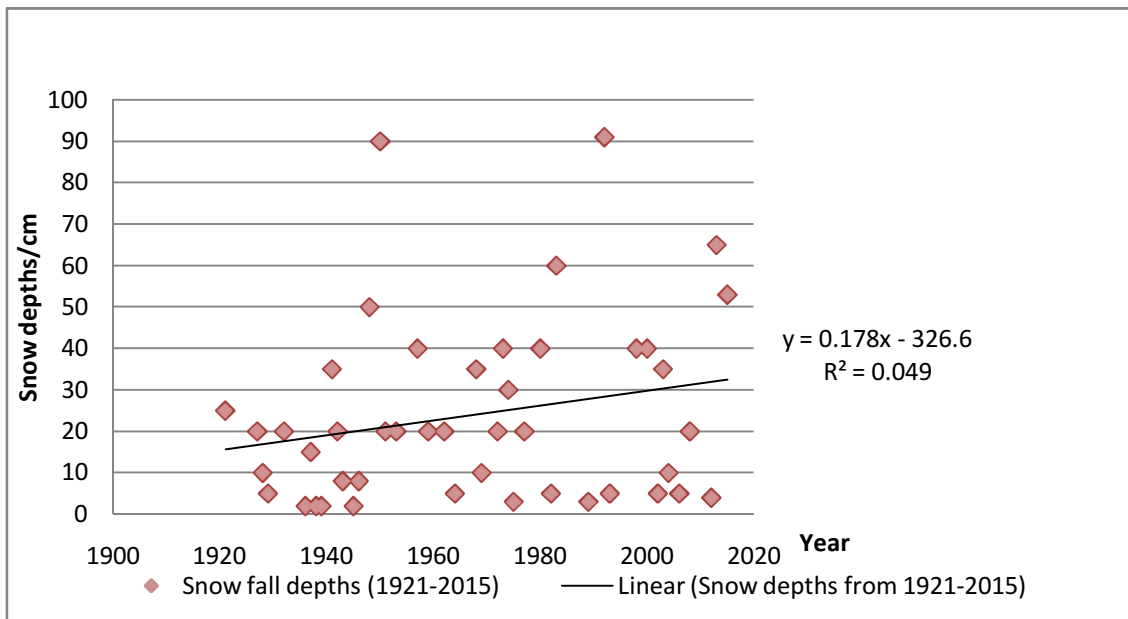


Figure (2.17): Increasing trend of snow fall in Jerusalem (1921 – 2015).

Due to the unexpected frequent and accumulated fall of snow, different companies and parties in the West Bank get affected by snow fall threat and have several losses.

To clarify the situation, Abdullah Salayma the director of "Al Mahaba" company for transportation in Hebron said that his company had a great financial loss. Losses estimated to be about 2 million shekels after the collapse of the company barracks on 8 trucks and a private car type "BMW" and stopped about 50 workers that working in the company. Figure (2.18) shown below illustrated the barracks collapse due to the extreme snow load in December 2013 (hebline, 2013).



Figure (2.18): Snow fall effects on Al Mahaba Company.

Source: (hebline, 2013).

In addition, there are different examples of the adverse effect of recent snow fall events such as the collapse of the physical education building in Birzeit University which occurred in February 2003 after a snow fall in the previous day. Losses were only of property due to the fact that the collapse was in the evening. Snow accumulation was ranging between 20-30 cm, failure was sudden and swift bringing most of the steel

structure down in seconds (Barakat, 2013). Further examples are illustrated in Annex (B).

Because of such losses, this research was made due to the importance of studying how to mitigate with the snow effects in the coming years and live with it as a normal situation, moreover, to respond to any similar risks quickly.

In order to study the snow effect on steel structures, the approach adopted in the Jordanian national building code (2006) for computing snow load is reviewed.

According to the Jordanian Code, the snow load on the roof can be estimated using the following equation:

$$S_d = S_o * \mu_i \dots\dots\dots (2.1)$$

Where:

(S_d) = Snow load on roof which represents the snow load density on the building roof (kN/m²).

(S_o) = Site snow load which represents the accumulated snow load density above building site (kN/m²).

(μ_i) = Snow load shape coefficient which represents the ratio between the snow load on the roof of the building caused by wind and the accumulated snow at the building site.

First, for snow load on roof estimation (S_d) and based on equation (2.1), site snow load (S_o) can be obtained from Table (2.7) which illustrates snow loads for different heights.

Table (2.7): Snow loads due to building heights

Snow load (S_o) kN/m ²	Height of structure from the sea (h) in meters
0	250 > h
(h-250)/800	500 > h > 250
(h-400)/320	1500 > h > 500

Source: (Jordanian national building code, 2006)

Secondly, for snow load shape coefficient μ_i estimation:

a. General rules:

The accumulated snow pattern depends on the wind speed and its direction, snow type, the outside shape of the building roof, and on ceilings places and heights. The code takes several modes for loads to make sure that all conditions are taken into account. Two cases of snow load distribution are:

- ✓ Case 1: the regular distribution of the snow that is likely to occur when the wind is light or not exist.
- ✓ Case 2: the accumulated snow fall when there is a wind

b. Roof shapes:

There are different shapes for roofs, the single span roof group will be discussed in this section, and it consists of the flat roofs and single-tilted roofs, the inclined roofs and the curved roofs.

➤ Flat and single tilted roofs:

For the first type, the snow load evaluated from the regular distribution of the snow on the entire roof of the building. In this case μ_i depends on the tilt angle of the building roof (α) and it is obtained from Figure (2.19).

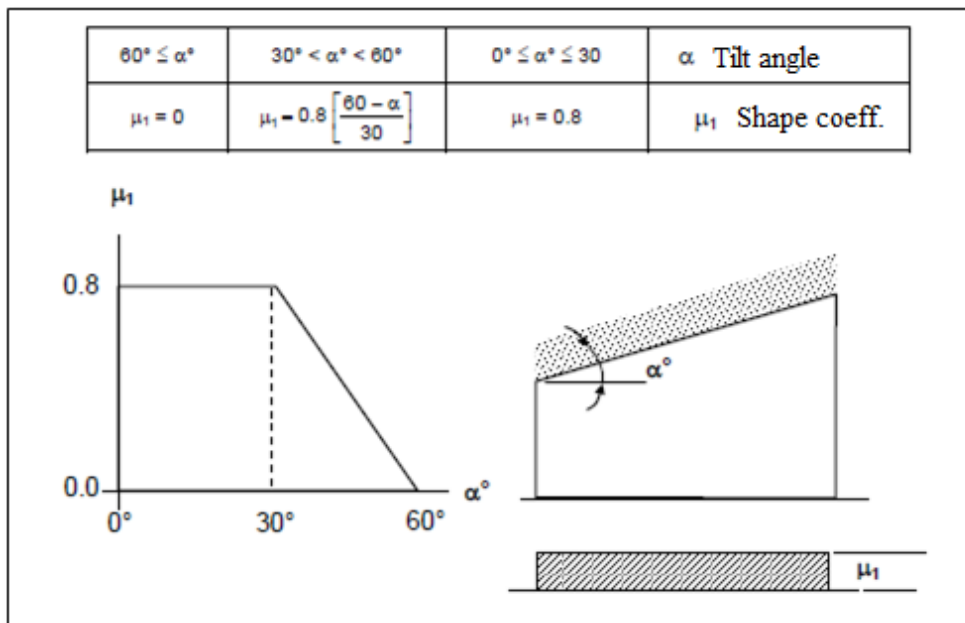


Figure (2.19): Shape coefficients for snow loads on the flat and tilted roofs.

Source: (Jordanian Code, 2006).

➤ Inclined / Tilted roofs:

For the inclined roofs, μ_i depends on the tilt angle of the building roof to its horizon and it consists of two situations, the first situation results from a regular distribution of the snow over the entire roof of the building and the value of shape coefficient to carry snow is obtained from Figure (2.20). In contrast, the second condition (asymmetric) results from the non-regular distribution of the snow over the roof and also obtained from Figure (2.21).

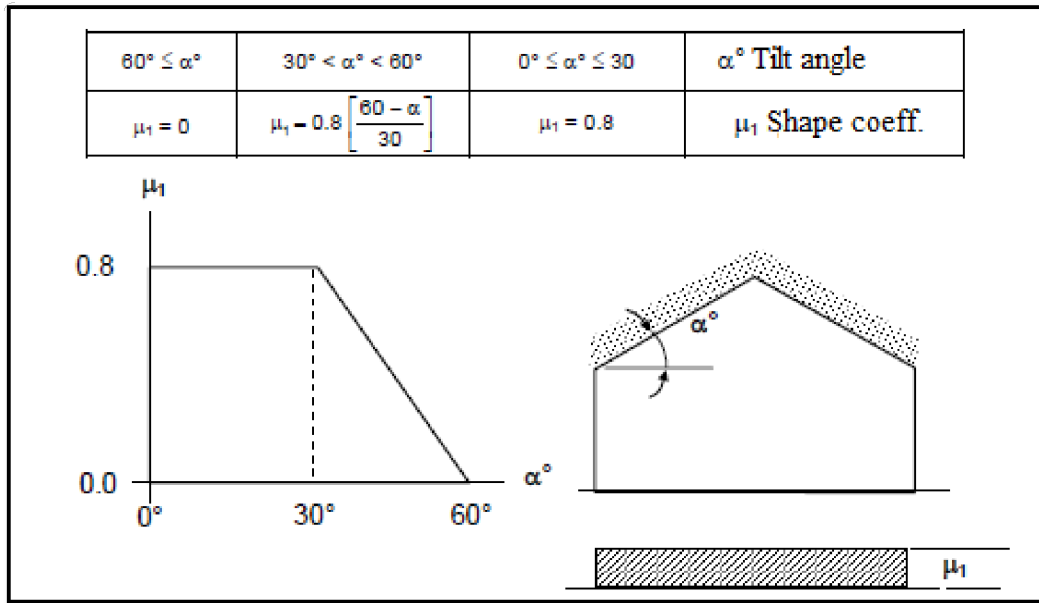


Figure (2.20): Shape coefficients for a regular snow loads on tilted roofs.

Source: (Jordanian Code, 2006).

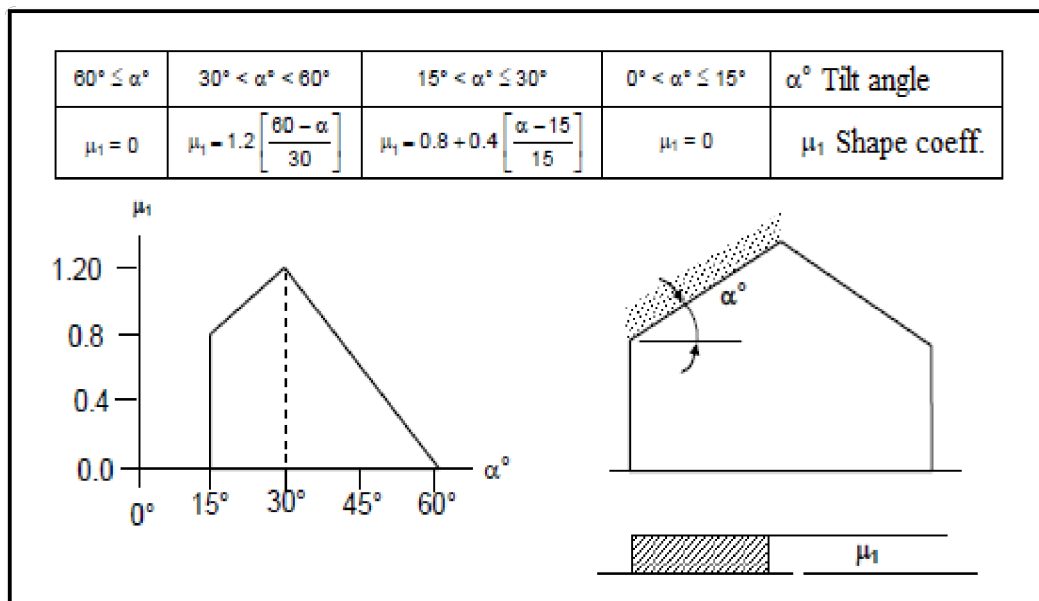


Figure (2.21): Shape coefficients for non-regular snow loads on tilted roofs.

Source: (Jordanian Code, 2006).

➤ Curved roofs:

For the regular load distribution on the curved roofs, μ_i depends on the equivalent inclination to the curved surface (β), and there are two types of the curved surfaces when determining the equivalent inclination, the first

situation when the angle between the horizon and the tangent curve not exceeds to 60° and the second situation results when the angle between the horizon and the tangent curve exceeds 60° . Figure (2.22) shows the curved roof calculations in order to find β and μ_i .

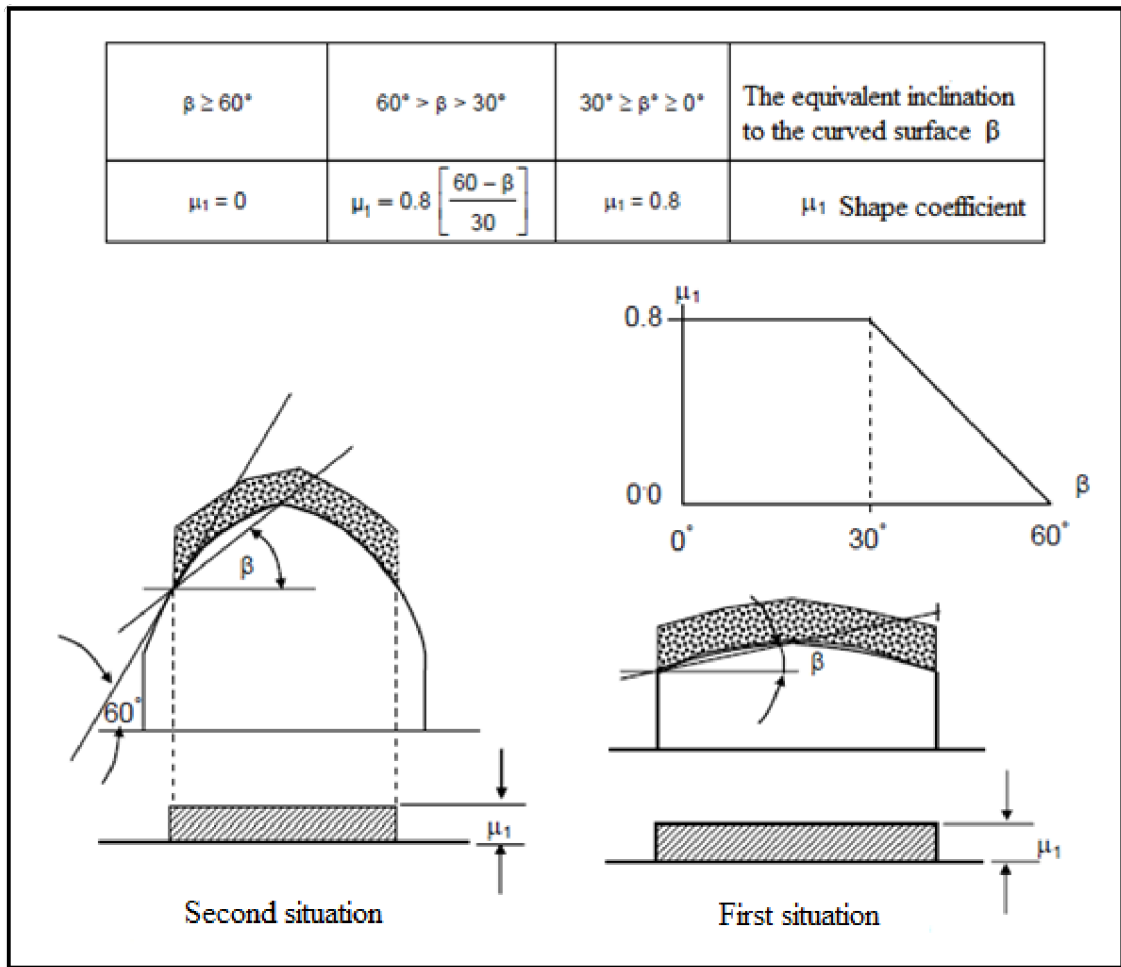


Figure (2.22): β and μ_i for regular distribution of snow loads on the curved roofs.

Source: (Jordanian Code, 2006).

Thirdly, it should be noted that snow load given by equation (2.1) is computed based on specific gravity of the snow which is around (0.1 - 0.4) and it is the average of (0.25), also it depends on the kind of snow. (Jordanian national building Code, 2006).

Load combinations:

Generally, engineering offices and companies in the WB use the UBC 97 to evaluate the load combinations for design purposes, where load and resistance factor design method (LRFD) is used. In the current research it was focused on the two main factors that may affect the structure which are the snow and dead loads and it was assumed the same load combinations in accordance with UBC 97 which include:

$$1.4D$$

$$1.2D + 1.6S$$

Where:

D: Dead load

S: Snow load

Nowadays, structures are designed with an extreme expected load as what is mentioned in the Jordanian code and the UBC code. Later in the structural analysis step, this research will examine the loads over steel structures and predict larger amounts of snow load than before, and then analyze it by using SAP programme; the last step will be about reaching results, alternatives and recommendation.

This is the end of risk in constructions category and the subjective aspects of how to respond to risks by adaptation or mitigation methods is viewed in the following sections.

2.5.8 Risk Adaptation and mitigation

➤ Introduction:

Natural hazards such as floods, droughts, landslides, snow-storms, wind-storms, and earthquakes exist everywhere around the world. Such dangers can pose the greatest threat to human lives, property, and economic development. There are several tools that have been developed to assist the hazard risk management process. There are also several mechanisms for hazards risk management, they are very important to improve the community preparedness and response (Olson and Wu, 2010).

In response to increasing evidence that climate change is occurring and has the potential to negatively impact human civilization, climate adaptation and action plans are becoming the primary mechanism for the reduction of climate changes and for management of risks. Communities can be creative and innovative by committing to working together for a better tomorrow for themselves and the next generations (Boswell, Greve and Seale, 2012).

When a hazard occurs, every minute is crucial to save lives, protect people, property and the environment and to react in a coordinated and conscious way which makes the real difference between a successful risk management and failure. The events caused by disasters are somehow repetitive and form a cycle that can be divided into four phases: mitigation, preparedness, response and recovery. The mitigation phase consists of all

actions needed to reduce the impact of future disasters. Preparedness phase comprises the actions taken to reduce the impacts when the disaster is forecast. Response pertains to actions taken during and immediately after the disaster, with the main aim to save and safeguard human lives. The term recovery refers to the process of restoring services and repairing damage after the disaster has struck (Di Franco and Salvatori, 2015).

There are two main responses that have emerged in recent decades to deal with climate change risk: mitigation and adaptation. Mitigation is the term of limiting climate change but adaptation is defined as “*the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*” (Wardekker, 2011). Many have speculated that increased attention to climate change adaptation will reduce support for mitigation (Carrico et al., 2015).

Mitigation is any action taken to reduce the extent of a disaster or potential disaster. Mitigation can take place before, during or after a disaster. Mitigation measures are either physical or structural. Successful mitigation measures will lower the risk. Two separate measures can be distinguished: Structural and non-structural mitigation. Therefore, for different hazards, different structural mitigation measures have to be used, e.g. building earthquake resistant houses, building dykes against flooding. Furthermore, the consequences of such mitigation measures can be different for each hazard (Hochrainer, 2006). *Adaptability* also means a

condition by which a state is able to adapt internally and externally to large-scale transformations of its natural environment (Djalante and Thomalla, 2012).

What are the main response pathways? As shown in Figure (2.23), the climate science can tell how ‘forcing’ within the climate system will induce changes in weather. Such outcomes will have their consequences or ‘impacts’, the severity of which will be determined by the level of vulnerability of a society that is sensitive to weather and climate. If the impact is sufficiently strong to elicit a response within the community, that response may take several forms. The side arms provide optional actions to reduce the negative impacts of the extreme events, either proactively or reactively (Troccoli et al., 2008).

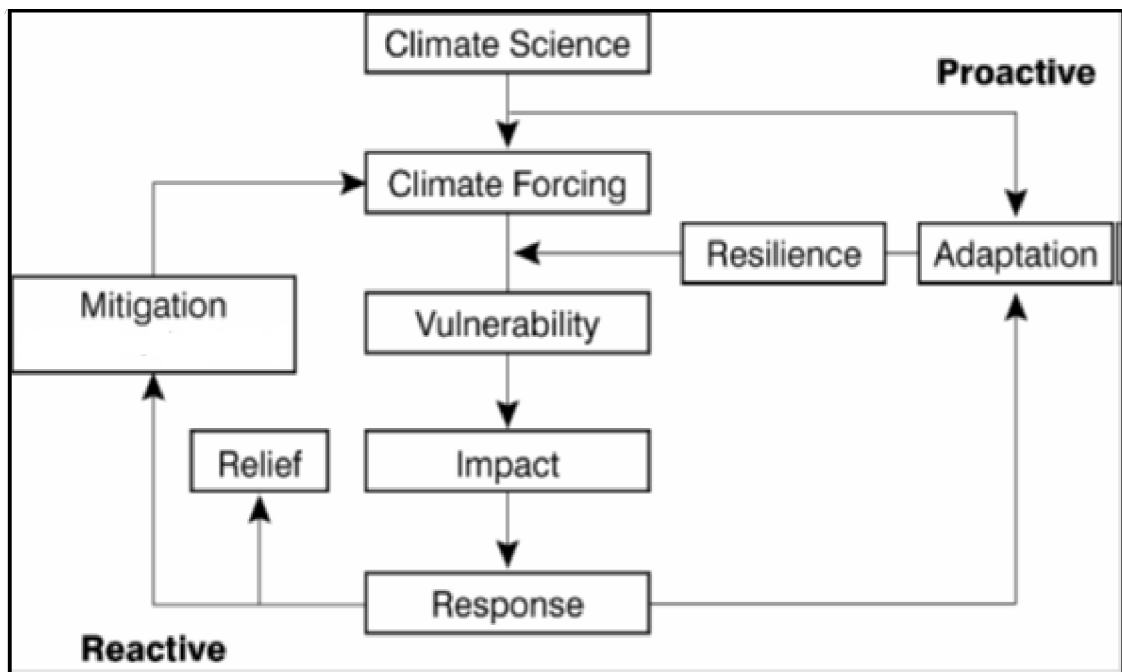


Figure (2.23): Responses pathways.

Source: (Troccoli et al., 2008)

c. Climate change adaptation planning in Palestine

In Palestine there are a number of challenges in the field of Disaster Risk Reduction (DRR), notably several extreme natural hazards such as earthquakes, floods, droughts and others (Dabbeek, 2010).

Regional climate change implications for Palestine over the next 50 years are expected to consist of several excess events which have been mentioned before. Different events are negatively affecting human and economic development in Palestine such as water resources, constructions, agriculture and public health. Civil society, private, and governmental sectors should be involved in the Palestinian adaptation programme of action by setting general plans and policies which can be addressed with a significant impacts (Arij, 2011).

➤ **Weaknesses and Limitations for Climate Change Planning in the WB (Arij, 2011):**

There could be different limitations faces the WB area related to CC planning such as:

- Limited legal frameworks for disaster risk reduction, which are response-led rather than preventative.
- Underdevelopment of policies for disaster preparedness, mitigation, and emergency response.
- Weak capacity in disaster management and rescue operations.

- Lack of capacity and training in disaster risk management and policy implementation at government level (national and local). Weakness or lack of studies on climate change.
- Lack of coordination between central and the local level authorities in disaster management activities.
- Limitations in using high technologies and devices used to monitor climate change issues.
- Scattered data (if exists) in different institutes and government and not easy to get it.
- Media coverage of climate change – both mitigation and adaptation.
- Low level of awareness of aspects of the environment, especially those related to climate change.

➤ **Summary**

There is a need for new legislation of the environmental information system (EIS) for better future planning, development of regional adaptation programmes. It is also essential to review previous work in all sectors to make sure that the new adaptation effort is not a duplication of other previous work (Arij, 2011).

According to Dabbeek (2011) there is a relationship between disaster and development, they affected each other in a way to be positive or negative. Development can impact the DRR by increasing the vulnerability

and taking into consideration disaster preparedness, in this way development can be really sustainable. Keys for linking sustainable development and disaster reduction are divided into two categories:

- * Good governance: includes participation, law rules, responsiveness, consensus building, effectiveness and efficiency.
- * Capacity building: includes training activities, hazards education programs and improvement of infrastructure.

There are different implementation strategies of hazard risk reduction which can be understood by stopping any increase of risk for new constructions and infrastructures by starting to decrease any unacceptable risk for the existing constructions and continuing to prepare for the consequences of expected hazards (Dabbeek, 2011).

Finally, well-informed and well prepared local communities and local governments can minimize the impacts of any hazard. Communities are varying from place to place, and their ways of responding to disaster also vary. Therefore, it is important to manage the community plans based on its needs and priorities. While pre-disaster preparedness is important, it is equally important to focus on post disaster recovery. The most important aim is to reduce the future risk and to have an effective sustainable development (Shaw, 2014).

Once the literature is concluded, the next section will describe the research methodology.

Chapter Three

Methodology

Chapter Three

Methodology

3.1 Introduction

After identifying and illustrating the goal of this study in the previous chapters, it is important to move on to identify the research type and then illustrate the research methodology.

There are several types of researches. In this study, an analytical & exploratory research will be conducted in order to analyze the current situation and find out ‘what is happening’ then to seek new insights and solutions.

3.2 Research approach

The research approach was divided into two main sections: the structural approach and risk management approach. Figure (3.1) describes the overall methodology which was used in this research.

To achieve the research objectives, data was collected from several directions:

- a. By first reviewing the existing literatures and publications on the main two concepts in this research.
- b. Secondly, data about snow fall depths was also collected from the Palestinian Meteorological Station (PMS) – Ramallah and from experts in order to prove that there is a change in the snow fall season and

needs to be studied, moreover to prove that there is a current CC in the WB and predict if it will be increased in the future.

3.2.1 Structural approach

To achieve the objectives of this study, SAP 2000 was basically used in the structural analysis. The following summarizes the main steps that were followed:

- 1) Interviews have been conducted with several companies that were negatively affected by the unexpected frequent snow fall, in order to determine and evaluate the damages that were occurred and how to avoid them in the next years, which give attention to the research importance for steel structures design. Figures of failure were shown in (4.1), (4.2), (4.3). Data was collected through interviews with different clients; basically with the clients of Jamaeen stone cut and from the clients of the Italian company. Through the interviews, several questions were asked mainly about the structure details, design, sections, materials, failure, members and losses which helped us in the evaluation and analysis step.
- 2) Evaluate the exist structures step: an interview with Jamaeen truss owner first was conducted in order to collect data about the stone cut truss which is made of steel structure, this case was taken as the first case study in the research. A second interview was made with Geneva Company staff; thirdly, the steel structure of the Italian company was also analyzed and taken as the second case study in the research.

- 3) Steel structures were analyzed and tested using SAP 2000 software in order to study their behavior under the expected snow load, for the first case study; Jamaeen stone cut truss, the snow and dead loads were estimated and related to Table (2.7) the snow load was calculated then the truss sections and members were identified, after that the truss was evaluated and the 3D view is shown in Figure (4.4) as the built design in reality, the 2D view of the truss is shown in Figure (4.5), the modal validation for the compatibility check is shown in Figure (4.6) and the equilibrium check is illustrated in Table (4.5). The Design result for the first case study truss is shown in Figure (4.7) which shows the truss safety. After covering the check for Jamaeen stone cut case study, the same analysis steps was performed for the Italian case study.
- 4) In the codes of design section, it was concluded that a modification to the snow load in the Jordanian code may be needed. A modification factor can be established related to the increasing snow fall in Jerusalem- Palestine shown in section (2.5.7) and based on the regression presented in Figure (2.17).
- 5) Additional interviews with control authorities like the ministry of local governments and Nablus Municipality were also conducted in order to collect more information about steel structures design laws, the engineers responsibilities, constructions monitoring and any additional instructions.

3.2.2 Risk management approach

The second step in the methodology of this research is “risk analysis” for snow fall accumulation on steel structures. Through implementing the risk management approach, the analysis helps to give insights for a successful adaptation and mitigation plans for the current risks facing our constructions.

The following summarizes the main steps that were followed:

- 1) The first step was analyzing the risk. Dangers and hazards that results from the snow fall over structures and may cause harm to assets, environment, people or other types was identified and illustrated in Table (4.7).
- 2) The second step is about identifying and analyzing the causes of the current risk, fault tree analysis method were used and illustrated in Figure (4.11).
- 3) The next step is about using the event tree analysis method in order to determine and analyze the possible event sequences that can possibly happened after the occurrence of the hazardous event and it is shown in Figure (4.13).
- 4) Data was analyzed also by using the Bow tie XP software, the bow-tie method and elements were illustrated in Figure (4.14) and described in Table (4.8)

- 5) Risk matrix analysis for three scenarios of the light, medium and high snow fall were also been used and shown for people, assets, environment and reputation in Figures (4.15), (4.16), (4.17), (4.18).
- 6) Risk was evaluated and control measurements were recommended in section (4.3.3). Risk management options for mitigation and adaptation options were mentioned in section (4.3.4).
- 7) After the analysis and management steps and before giving the last conclusions and recommendations, a brainstorming session was conducted at An Najah National university- Engineering college, specialized Doctors mainly in constructions and management and MSc students attended the session and suggested additional insights for achieving best risk management (mitigation and adaptation) practices in the WB. List of attendance are attached in Annex (C).

Based on the data collected and analyzed above, conclusions, recommendations and suggestions for future work studies will be drawn. Figure (3.1) below illustrates the whole process.

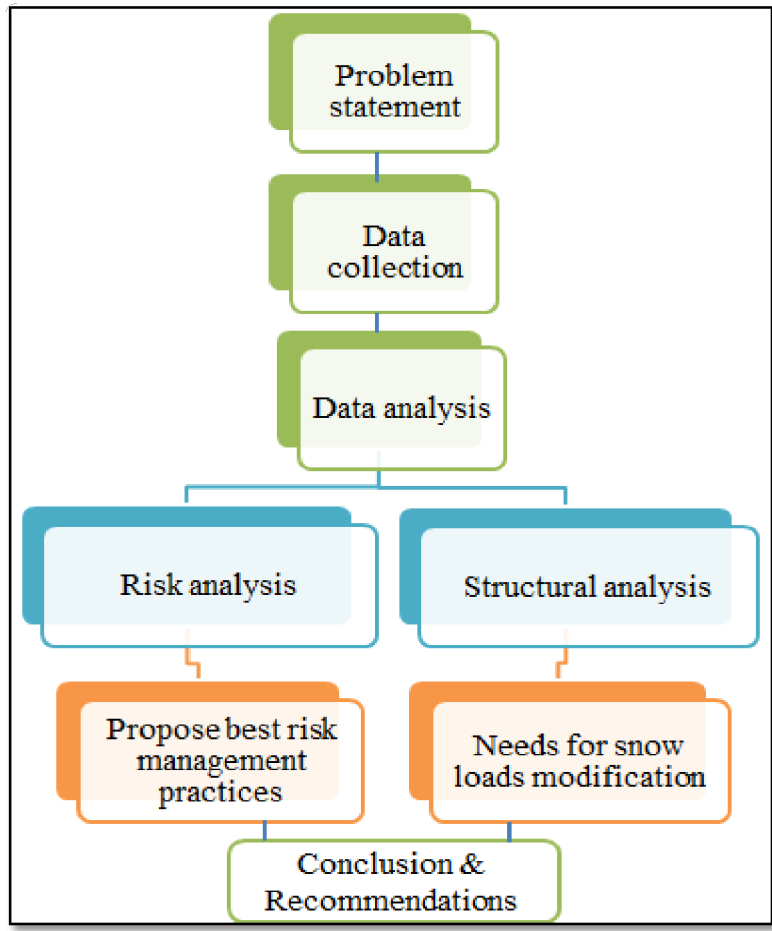


Figure (3.1): Methodology flowchart of the research.

Chapter Four
Data Analysis, Results
and Discussion

Chapter Four

Data Analysis, Results and Discussion

4.1 Overview

In this chapter, the data that have been collected through the literature and interviews based on the mentioned techniques and process was analyzed as described in the previous chapter. The analysis is divided into two steps; the structural analysis and risk analysis. At the end of the two steps, patterns that make up the research results were identified.

4.2 Structural analysis

4.2.1 Introduction

From the foregoing, it is revealed that there is an increase in the snow loads over constructions. As an illustration, different steel structures were affected by the recent extreme snow fall such as Jamaeen stone cut, Geneva Company and the Italian company. Some pictures of the failure of these structures are shown in the figures below.



Figure (4.1): Snow fall effects on Jamaeen stone cut truss.



Figure (4.2): Snow fall effects on Geneva company truss.

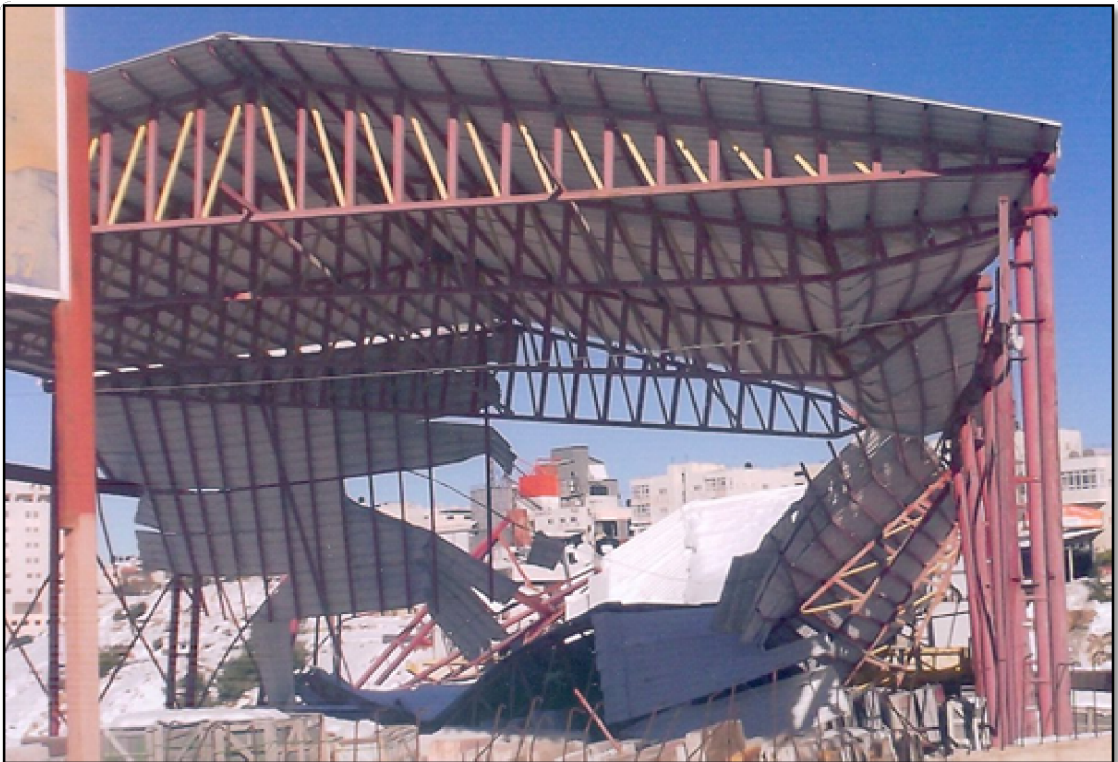


Figure (4.3): Snow fall effects on the Italian company truss.

Additional pictures are given in Annex (B).

In this research, two main cases were chosen to be analyzed and checked. An analysis for them is presented below.

4.2.2 Collapse due to snow load – Case studies

1. Jamaeen case study

The first case exists in Jamaeen town which is located to the southwest of Nablus city in the WB and located about 16 kilometers far from the city, the town rise from sea level by about $h= 530$ m. The structure had an area of 375 m^2 . It was affected by 2013 snow fall and had losses of around 50,000 shekel.

The structure was checked and analyzed using SAP 2000 software.

➤ SAP 2000 analysis

Based on equation (2.1) and by using the Jordanian code, snow load rating in kN/m^2 might be estimated; (S_d) was calculated as giving below:

$$\text{Site snow load } (S_0) = (h-400)/320 = 0.4$$

From Figure (2.20), snow load shape coefficient (μ_i)= 0.8

$$\text{Thus: snow load on roof } (S_d) = S_0 * \mu_i = 0.4 * 0.8 = 0.32 \text{ kN/m}^2$$

Loading

The structural elements are subjected to the following loads:

- a) Dead load: calculated from self-weight by the software.

- b) Dead load from purlins and ceiling cover = 0.6 kN/ m
- c) Snow load = $S_d * \text{Tributary Area} = 0.32 * 5 = 1.6 \text{ kN/m}$

Materials and steel sections

The used materials and steel sections are:

- a) Steel type A36 was used.
- b) Frame sections are illustrated in the Tables (4.1), (4.2), (4.3) below.

Table (4.1): Pipe frame sections

Material	Outside diameter (m)	Wall thickness (mm)
Pipe section 1	0.1	5
Pipe section 2	0.25	5
Pipe section 3	0.15	5

Table (4.2): Tube frame section

Material	Outside depth (m)	Outside width (m)	Flange thickness (mm)	Web thickness (mm)
Tube section	0.15	0.1	3	3

Table (4.3): IPE frame section

Material	Outside height (m)	Top flange width (m)	Top flange thickness (mm)	Web thickness (mm)
IPE 240	0.24	0.12	9.8	6.2

- c) Area section that was used in the structure is shown in Table (4.4).

Table (4.4): Ceiling cover area section

Material type	Membrane (mm)	Bending (mm)	Type
Steel A 36	5	5	Shell thin

Evaluation of steel truss:

The 3D view for the structure is represented in Figure (4.4) below as built design in reality, it can be noticed that the ceiling cover is colored by

the green color. The white lines is for pipe section 2, the blue lines is for pipe section 1, the cyan color is for pipe section 3, and the dark pink color represents the tube section. Finally the IPE 20 section is colored by the gold color. Support conditions are considered simple as shown in Figure (4.4).

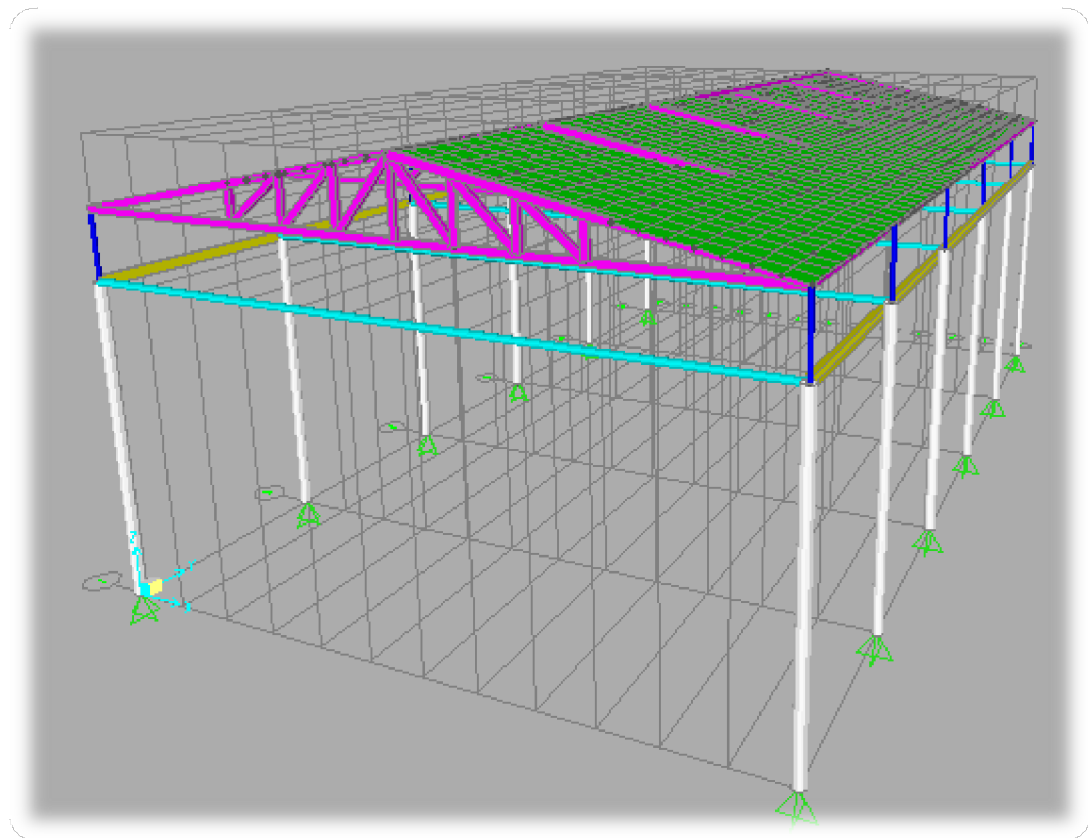


Figure (4.4): 3D view for the first case study truss in SAP software.

2D analysis was carried for the truss rather than the 3D analysis because of the instability of the truss and the truss was not designed with bracing. An interior truss was chosen to be designed as shown in Figure (4.5) below.



Figure (4.5): An interior truss from the first case study in SAP software.

Model validation:

To validate SAP model of the structure, two checks are performed, namely compatibility check and equilibrium check.

➤ Compatibility check:

Figure (4.6) shows the whole structure deforms smoothly which implies that compatibility is satisfied.

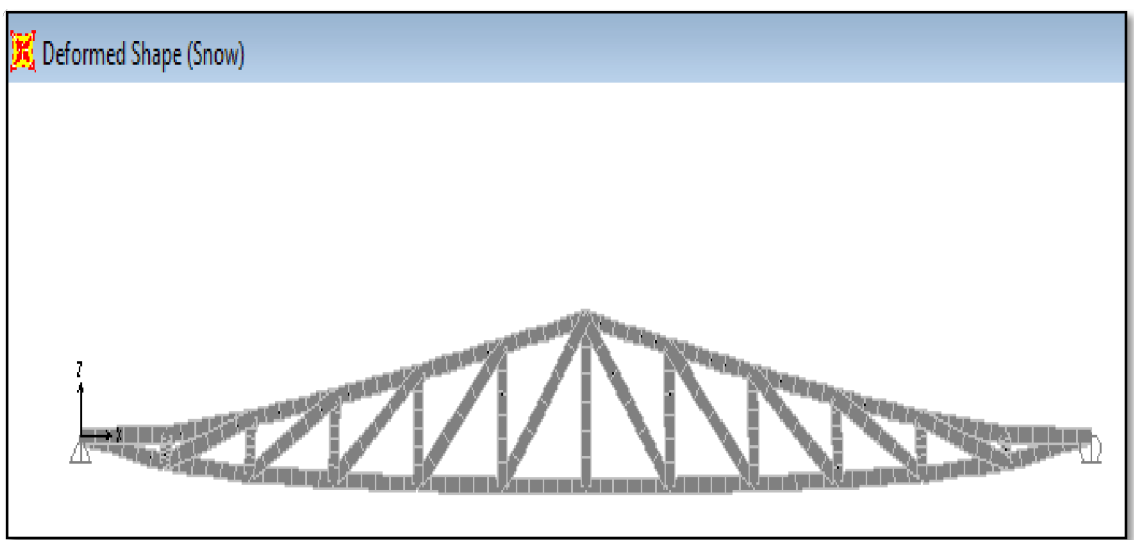


Figure (4.6): Compatibility check in the first case study truss.

➤ Equilibrium check:

Equilibrium check is satisfied according to the results that shown in Table (4.5).

Table (4.5): Equilibrium check results for the first case study.

Reaction results from Loads	Total SAP load (kN)	Total manual load (kN)	Error
Dead load	15.44	15	0.029
Snow load	24.48	24	0.02

Calculations for the manual load are illustrated below:

✓ Snow load:

$$\text{Snow load} = \text{load} * \text{tributary area} = 0.32 * 5 = 1.6 \text{ kN/m}$$

$$\text{Total load (Snow)} = 1.6 * 15 = \mathbf{24 \text{ kN}}$$

✓ Dead load:

$$\text{Dead load from purlins and ceiling cover} = 0.6 \text{ kN/ m}$$

$$\text{Dead load from truss members} = 6 \text{ kN}$$

$$\text{Dead load} = 6 + (0.6 * 15) = \mathbf{15 \text{ kN}}$$

It should be noted that the dead load and snow load errors were < 0.05 which are acceptable according to codes of practice.

According to the previous, checks assured the validity of the model for the analysis of the case studies.

For the current steel design, (AISC360-05/IBC2006) design code was used in order to check the truss safety. Results are shown in Figure (4.7) below, colors in the figure represents the utilization ratio which is defined as the fraction of load by capacity, starting by the cyan (safe) color to the red (not safe) one, indeed figure manifest that the truss is safe under the loads according to the Jordanian loads code.

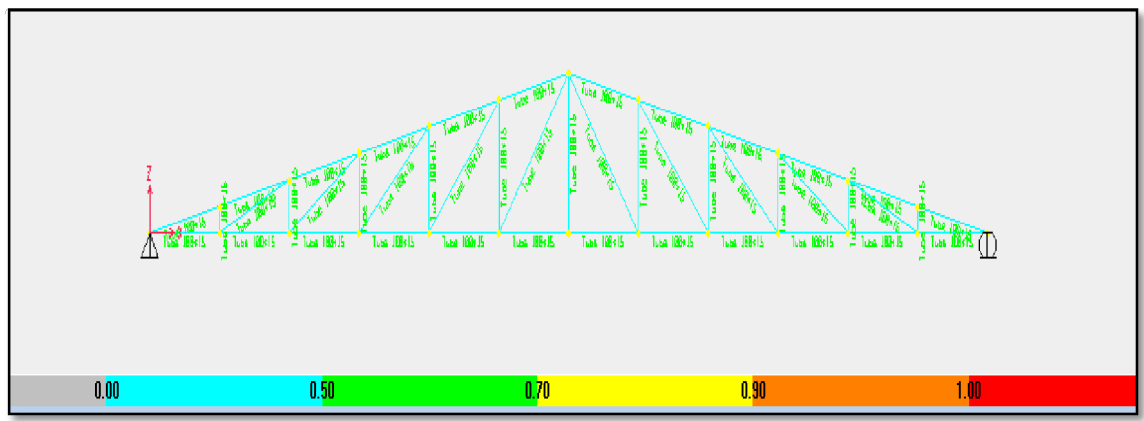


Figure (4.7): Design result for the first case study truss.

After covering the check for Jamaeen stone cut case study, the same analysis steps can be performed for the Italian case study as the illustration below.

2. Italian company case study

The second case exists in Ramallah city which rise from the sea level by about $h= 860$ m. The structure had an area of 1200 m^2 ; it was affected by 2013 snow fall and had different losses about 1 million shekel.

The structure was analyzed by SAP 2000 software and gives also safe results as described below.

➤ **SAP analysis**

Based on equation (2.1):

$$S_0 = 1.44$$

$$\mu_i = 0.8$$

$$\text{Then: } S_d = 1.15 \text{ kN/m}^2$$

Loading

The 2D structural elements are subjected to the following loads:

- a) Dead load: calculated from self-weight by the software.
- b) Dead load for purlins and ceiling cover = 0.6 kN/m
- c) Snow load = $S_d * T.A = 1.15 * 2\text{m} = 2.3 \text{ kN/m}$

Materials

The materials are:

- a) Steel type A36 was used.
- b) Tube section frame 15*100 were used in the structure.

Design for steel truss

The 2D view for the truss is shown in Figure (4.8) below.

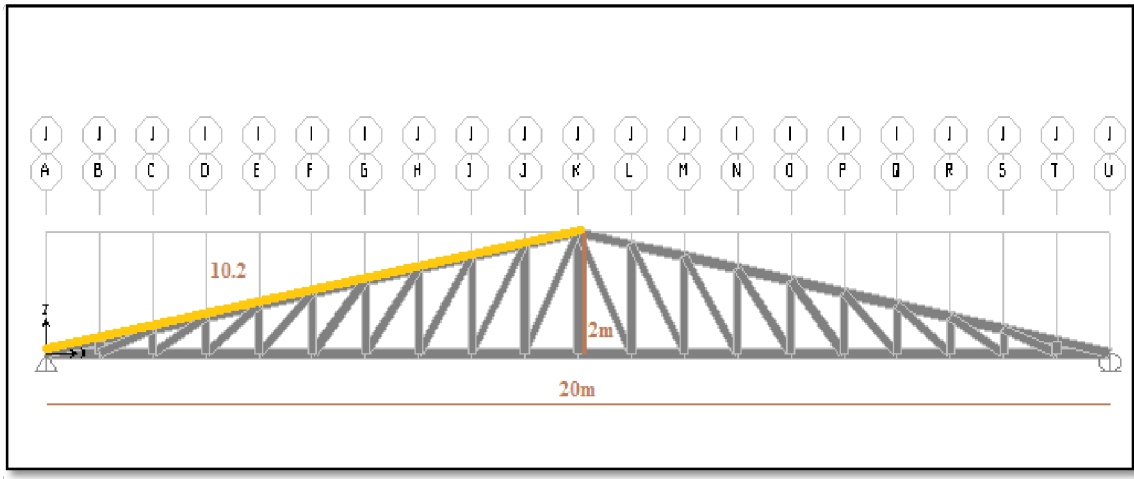


Figure (4.8): 2D view in SAP for second case study.

Model validation

➤ Compatibility check:

Figure (4.9) shows that the structure deforms smoothly which implies that compatibility is satisfied.

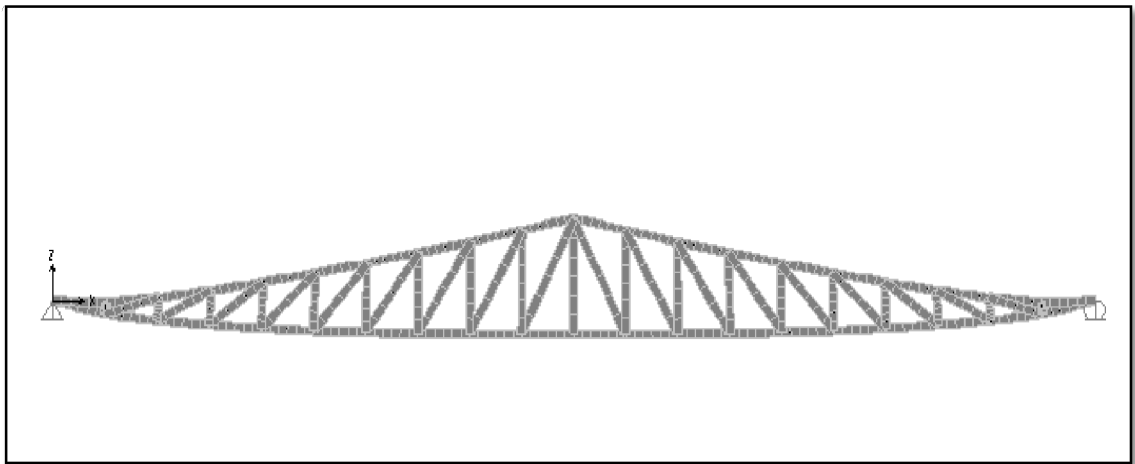


Figure (4.9): 2D deformed shape in the second case study.

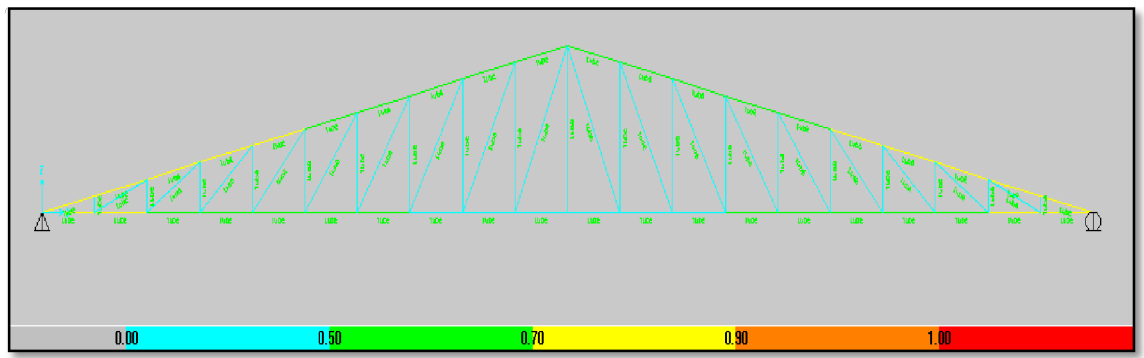
➤ Equilibrium check:

Equilibrium check is satisfied according to the results that shown in Table (4.6).

Table (4.6): Equilibrium check results for the second case study.

Reaction results from Loads	Total SAP load (kN)	Total manual load (kN)	Error
Dead load	22	21	$0.047 < 0.05$ OK
Snow load	47	46	$0.021 < 0.05$ OK

For Steel Design, Figure (4.10) below clarify that the structure is safe under the calculated loads which depends on the Jordanian code.

**Figure (4.10): Safe design for the steel truss in the second case study.**

After analyzing the two cases, it can be concluded that the used sections in the trusses were safe under the loads according to the Jordanian code.

4.2.3 Codes of design

Several Structures were collapsed in the last few years, causes of such event may be related to the unexpected snow load, the instability of the structure, improper design of the structural members and connections, combined natural events (of wind and snow) or combined human and natural events. Additional description is illustrated in the risk analysis section (4.3) page (96).

Until recently, snow loads used for design practices in Palestine are determined based on the Jordanian Code requirements. Despite the fact that the snow load in the above case studies was computed based on the Jordanian Code, these cases appeared to be unsafe under certain substances; therefore, a modification to the snow load in the Jordanian code may be needed.

An illustration on how such a modification factor can be established is presented here. In relation to the increasing snow fall in Jerusalem-Palestine shown in section (2.5.7) and based on the regression presented in Figure (2.17), an increase of snow depths of about 10% every 20 years can be suggested. This value represents a key value for modifying the snow loads in the conditions where these loads in the code appear to be unsafe.

The second subject that thesis focuses on is risk analysis.

4.3 Risk analysis process

4.3.1 Risk analysis

This section illustrates the second phase of analysis which is related to analyzing the risk that may results from the accumulated and frequent snow fall over steel structures and defined as “Risk Analysis”.

As what have been mentioned before, “Risk” is related to what can happen in the future; it can be analyzed and managed in rational ways. RA is essential in order to predict and reduce the risk of occurrence of an accident in any system.

During the analysis, it will be clearly shown that risk assessment and risk management are two parts of the RA process. RA involves developing an understanding of the risk, and finally it provides an input to risk evaluation and to decisions on whether risks need to be treated as it is shown at the end of this section.

The selection of suitable risk analysis technique is critical to the entire risk management process. The qualitative risk analysis technique is used during the analysis.

In order to perform an effective RA process for the current situation of the research, answers must be given to the following three important questions (Munier, 2014):

1. What can happen? Or what can go wrong?
2. What is the probability of its happening?
3. If this, indeed, does happen, what are the consequences?

Starting by giving answers to the three main questions:

➤ **Hazard identification (HI):**

HI is the step of finding, recognizing and describing risks. To deal with the first question: What can happen?, dangers and hazards that results from the snow fall over structures and may cause harm to assets, environment, people or other types should be identified. Table (4.7)

illustrates the possible hazards and hazardous events that may results from the following scenarios.

Table (4.7): Hazard & Hazardous events

Scenarios	Hazardous Events
Scenario one: Light Snow Depth = 0-15 cm	1- Slight damage to property, materials, constructions and infrastructure 2- More consumption of fuel/electricity and leads to more pollution to the environment
Scenario Two: Medium Snow Depth = 15 -30 cm	1- More car accidents which leads to human injuries 2- Damage to property, materials and infrastructure 3- Loss in agricultural crops due to cold temperatures 4- Pollution caused by higher consumption of fuel. 5- Municipality reputation for clearing roads from snow. 6- Hospital capacity might not be enough.
Scenario Three: Heavy Snow Depth = 30 cm to more	1- More car accidents which leads to human injuries 2- Severe damage to property, materials and infrastructure which might cause the collapse of structures, roads, mountain sides. 3- Loss in agricultural crops due to cold temperatures, floods 4- Trapped in people in remote locations. 5- Loss of vehicles. 6- No accessibility. 7- Pollution caused by higher consumption of fuel. 8- Municipality reputation for clearing roads from snow. 9- Hospital capacity might not be enough.

➤ **Causal and frequency analysis:**

In order to deal with the second question: How will the hazardous event occur?. It is important to analyze and identify the possible causes of the hazardous event.

To identify and analyze the causes of the current risk, fault tree analysis method were used and illustrated in Figure (4.11).

As it is shown in Figure (4.11), by starting with the top event (Structure failure due to the accumulated snow fall), it is the potential critical event in the system and called the TOP event of the fault tree. The immediate causal events will lead to the top event and connected to top event through a logic gate.

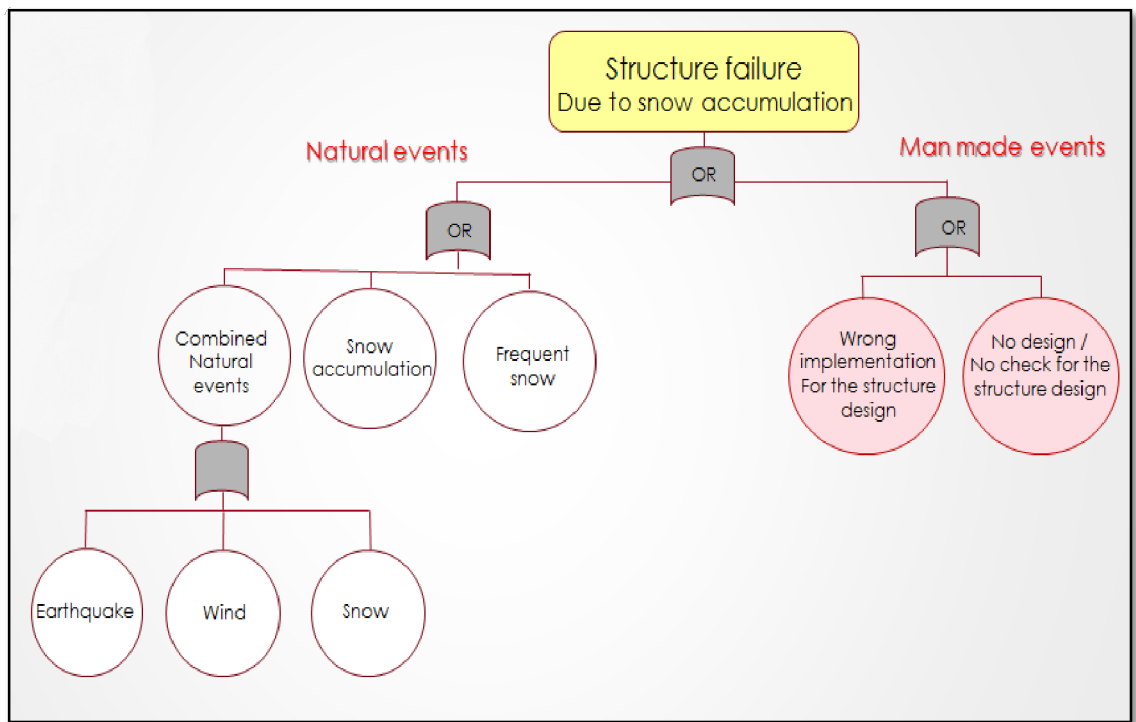


Figure (4.11): Fault tree diagram.

From figure (4.11), it is clearly noticed that the structure failure which is the “Top event” may be caused first, by natural events such as the accumulated or frequent snow events or a combined natural events may occurred. Secondly, by man-made events such as the structure may had not been designed or it may had a wrong implementation for the structure design by the contractor or the engineer, also a combined events of natural and man-made events may occurred and caused the failure.

It is also noticed that the (OR) gates were used in the diagram by generating the output if at least one of the inputs exists, (AND) gate may be used when the both inputs will occur.

Figure (4.12) below shows the fault tree symbols.

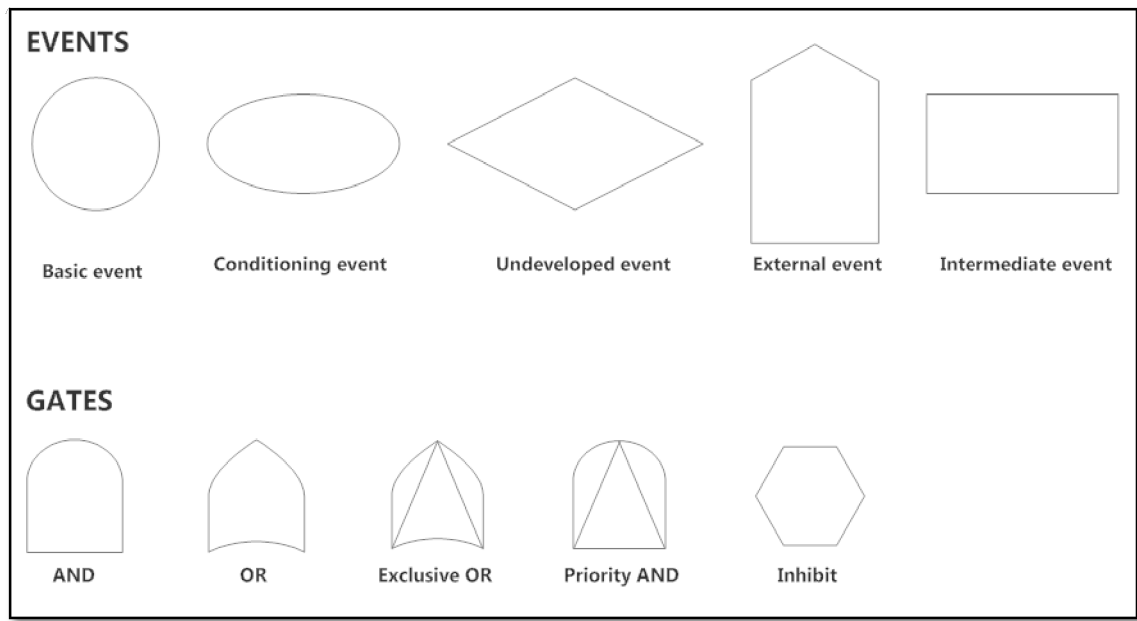


Figure (4.12): Fault tree diagram symbols.

Source: (Smartdraw.com, 2016)

After illustrating the fault tree diagram, analyzing the accident scenario by using the event tree diagram will be discussed below.

➤ Accident Scenarios analysis

Analyzing the third question can be performed by answering “How can the possible consequences of a hazardous event be determined?”

To determine and analyze the possible event sequences that can possibly happened after the occurrence of the hazardous event, event tree analysis method will be used for modeling and analyzing the possible

accident scenarios. As it is shown in Figure (4.13), the resulting diagram displays the possible accident scenarios that may follow the hazardous event of snow accumulation.

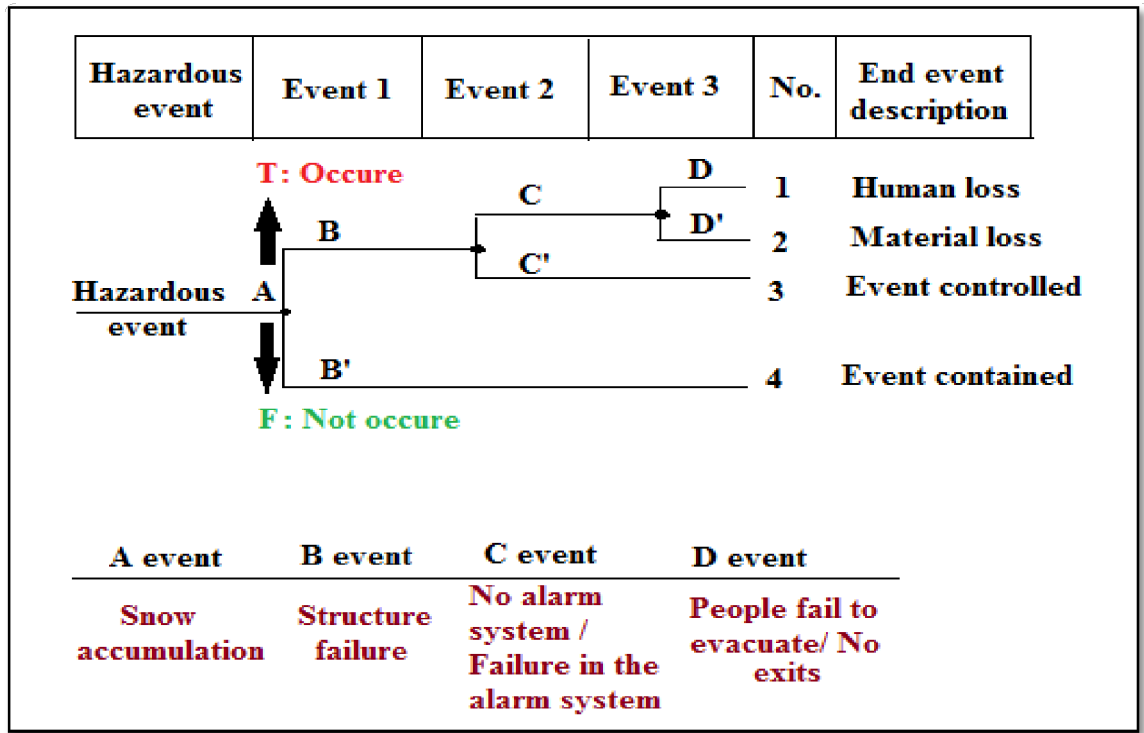


Figure (4.13): Event tree diagram.

In Figure (4.13), “Event B” describes the failure of the structure, “Event C” describes a failure in the alarm system, and “Event D” illustrates the failure of people evacuation. Moreover, several additional failure events scenarios could be also suggested to the current situation such as to have “Event E” which is the failure or existence of the safety and emergency equipment/ emergency responders.

After identifying the possible event sequences, the “end event description” could be clearly described if the previous events occurred or not, for example for the first row of occurrence the snow accumulation event, structure failure event, alarm failure event and the event of not

evacuation, it could lead to high probability of human loss or injuries and that's could be identified as the worst case of occurring such event.

Finally, after answering the main three questions, RA is conducted for the current situation and new insights for a successful assessment will be suggested at the end of this chapter.

Additionally, Bow tie analysis and risk matrices are also used and illustrate the overall risk analysis. First, the Bow tie Model was used to examine the hazardous events and threats. Also barriers and controls are shown in Figure (4.14) below.

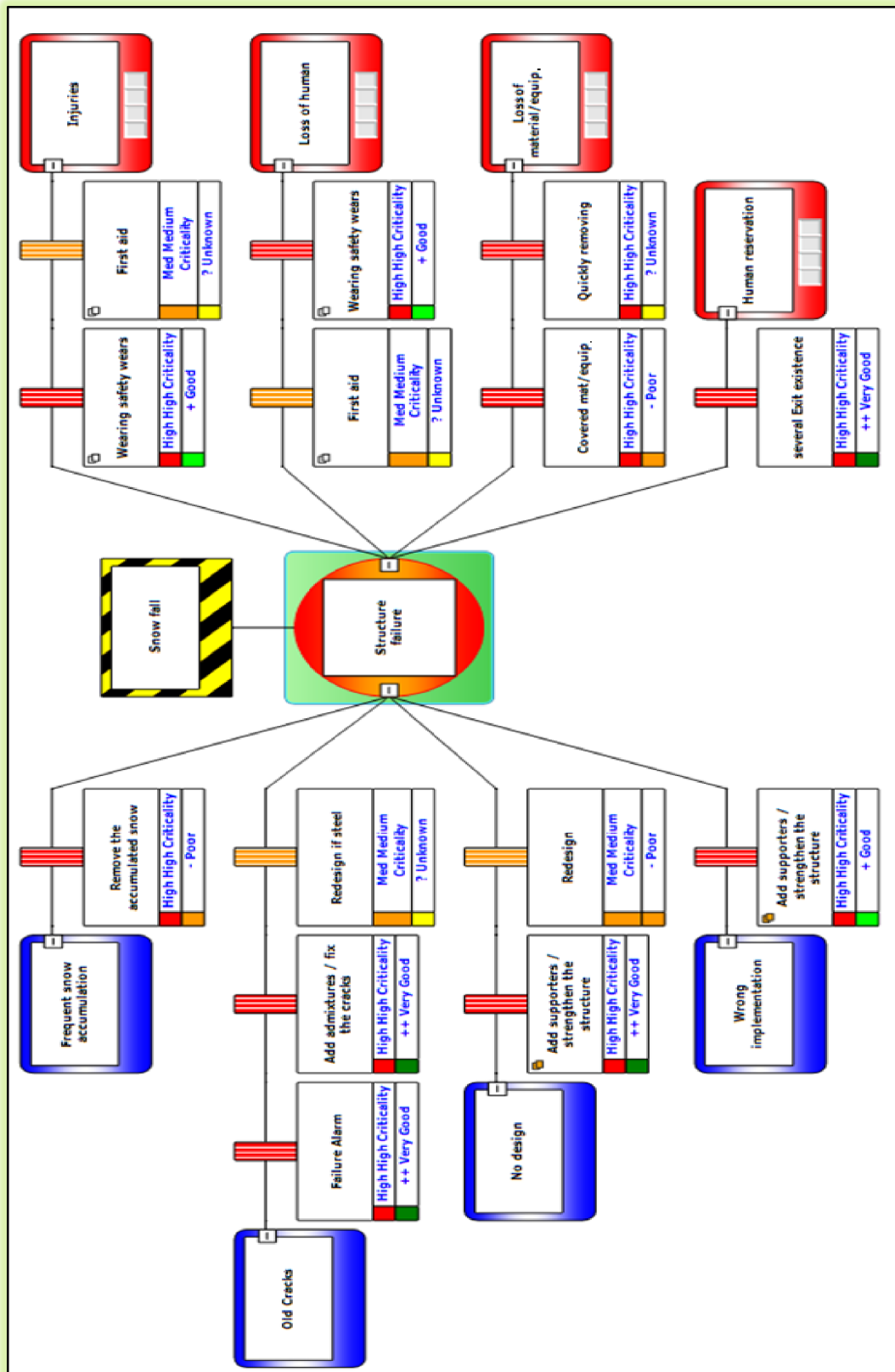


Figure (4.14): Bow tie model.

Elements that were used in the Bow tie model are described below in Table (4.8).

Table (4.8): Bow tie model elements.

Events	Barriers of the events	Hazardous event	Barriers of the consequences	consequences
Frequent snow accumulation	Remove the accumulated snow	Structure failure due to snow accumulation	The existence of safety and emergency response / equipment / First aid	Injuries or Loss of human
Old cracks in the structure	Re-design/ add admixtures			
No Design for the structure	Re-design/ add supporters		Covered / Quick remove	Loss of materials/ equipment
Wrong implementation of the structure design	Re-design/ add supporters		Several exit existence / quick emergency response	Human reservation

Secondly, for the risk matrices, three scenarios were examined, light snow, medium snow and heavy snow. For each scenario of snow, the effect/consequences have been listed on four elements: people, assets, environment and reputation, and they are described below:

a) People risk matrix:

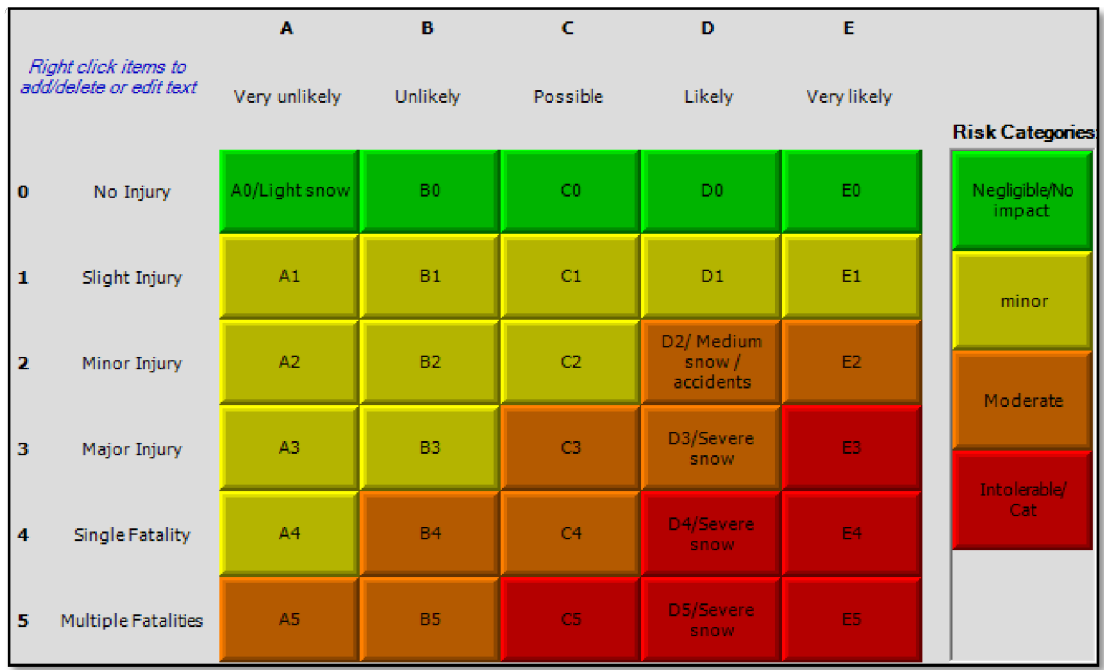


Figure (4.15): People risk matrix

As it is shown in Figure (4.15), for the light snow, the effect on people was negligible (A0 – Green color). However, for Medium snow the effect on people is Minor (D2 –Orange color) with possibilities for light injuries due to car accidents. As for the heavy snow, it might cause more injuries due the possibility of more severe car accidents, people could also be trapped in different locations and be more exposed to injuries, hypothermia and collapsing accidents and that puts the risk on people between moderate and intolerable (D3 orange -D5 red colors) in case of fatality existence.

b) Assets risk matrix:

		A	B	C	D	E	
		Very unlikely	Unlikely	Possible	Likely	Very likely	
0	No Damage	A0	B0	C0	D0	E0	No impact
1	Slight Damage	A1	B1	C1/Light snow/ restriction of movement	D1	E1	Minor
2	Minor Damage	A2	B2	C2	D2	E2	Moderate
3	Localised Damage	A3	B3	C3	D3/Medium snow	E3/ Severe snow	Intolerable/Cat
4	Major Damage	A4	B4	C4	D4/Severe snow	E4	
5	Extensive Damage	A5	B5	C5	D5	E5	

Figure (4.16): Assets risk matrix

From Figure (4.16), the light snow may have a slight effect on assets with damage to materials and was found to be minor effect (C1- Yellow

color). However, for medium snow, the effect on assets is considered moderate because of car breakdowns, leakage in buildings, less accessibility to certain locations and maybe loss in materials especially for construction and industrial zones and is classified to have moderate effects (D3- Orange color). As for the heavy snow, it might cause substantial loss in assets, such vehicles, buildings, materials and infrastructure, the risk was classified as intolerable (E3-D4 Red colors) as what happened in "Al Mahaba" company for transportation which was discussed before in Figure (2.18).

c) Environment Risk Matrix:

		A	B	C	D	E	
		Very unlikely	Unlikely	Possible	Likely	Very likely	
0	No Effect	A0	B0	C0	D0	E0	No impact
1	Slight Effect	A1	B1	C1/ light snow / pollution	D1	E1	Minor
2	Minor Effect	A2	B2	C2	D2	E2	Moderate
3	Localised Effect	A3	B3	C3	D3/ Medium snow	E3/Severe snow	Intolerable/ catastrophic
4	Major Effect	A4	B4	C4	D4/Severe snow	E4	
5	Massive Effect	A5	B5	C5	D5	E5	

Figure (4.17): Environment risk matrix

As it is shown in Figure (4.17), the light snow may have a slight effect on the environment with more pollution because of the

heat/electricity increased consumptions (C1- Yellow color). However, for medium snow the effect on environment is considered moderate because of the pollution plus any damage that might reach crops and agriculture (D3- Orange color). As for the heavy snow it might cause substantial effect on the environment, such as pollution increase a lot, plus the severe damage to agriculture and crops and floods that might be cause by the heavy snow, the risk was classified as Intolerable (E3-D4 red colors).

d) Reputation Risk Matrix:

		A	B	C	D	E	
		<i>Right click items to add/delete or edit text</i>					
		Very unlikely	Unlikely	Possible	Likely	Very likely	
0	No Impact	A0	B0/light snow	C0	D0	E0	No impact
1	Slight Impact	A1	B1	C1	D1	E1	Minor
2	Limited Impact	A2	B2	C2	D2	E2	Moderate
3	Considerable Effect	A3	B3	C3	D3/Medium snow	E3	Intolerable
4	National Impact	A4	B4	C4	D4	E4	
5	International Impact	A5	B5	C5	D5	E5	

Figure (4.18): Reputation risk matrix.

Figure (4.18) illustrates that the light snow may have a slight effect on reputation as minimum damage to structures and infrastructure which will not affect many establishments and was rated with ‘No Impact’ (B0 - Green color), as for the medium snow, the damage to reputation is considered moderate (D3- Orange color). Some establishment’s reputation

maybe affected such as municipality and services provided to clear the snow and capability of hospitals to take all injured people, also electricity and water company reputations maybe affected. All of the above establishments are extremely affected if we have heavy snow as their job becomes harder and is rated intolerable (D4- Red color).

After analyzing the whole event of hazards, barriers and consequences for the current hazardous event, the next step is to find the appropriate control measures and suggest new solutions in order to reduce the adverse effects which are concluded within the evaluation step of risk assessment as it will be described in the next section.

4.3.2 Risk evaluation

As what have been mentioned previously, the purpose of risk evaluation is to help taking decisions, based on the outcomes of risk analysis, about which risks need to be controlled, treated and the priority for treatment implementation.

From the Bow tie model, it can be noticed that there is some proposed controls, such as redesigning the structure or adding admixtures or supporters. Moreover there is another controls can be suggested and taken into consideration, such as:

1- Removal of accumulated snow:

a) Pre-Snow: as dictated by weather forecasts, hills, curves and streets will be treated with a salt spray prior to the forecasted snow event.

b) During and after Snow: depending on snow depth, the municipality decides whether to remove snow using municipality vehicles or not.

2- Maintenance of structures, includes:

a) Regularly inspect building elements including parapets, cornices, window lintels, exterior walls, and roofs.

b) Clear roofs and overhangs of snow and ice, and clean gutters and roof drains before and after a snow or ice storm.

c) Repair sagging ceilings, to better withstand snow load.

d) Replace all damaged roof joints.

e) Install insulation and high-performance windows: multi-paned windows with reflective coatings that lower winter heat loss and heating costs.

f) Protect internal building infrastructure by fitting exposed pipes with insulation sleeves or otherwise wrapping them, to slow heat transfer.

g) Seal cracks and holes in outside walls and foundations near water pipes.

4.3.3 Risk assessment

As what have been mentioned before, once threats are identified, they must be assessed. In the current research, after carrying out the risk analysis and evaluation, risk assessment has been achieved.

4.3.4 Risk management

After identifying, analyzing the current situation of snow fall accumulation, making plans and developing mitigation approaches for the critical risks, tracking mitigation and adaptation plans are the next steps. The communication step throughout the process will ensure a free-flow of information, after implementing the previous steps, risk management will be achieved. Several additional options were suggested through the brainstorming session.

Adaptation & Mitigation options

According to the Federal Emergency Management Agency (FEMA, 2014), the purpose of such options is to establish a wide directive options to integrate the adaptation planning and actions into programs, policies and operations.

Moreover, as what have been mentioned before, “Hazard mitigation is any action taken to reduce to eliminate long term risk or people and property from natural disasters” (Fema.gov, 2016). The purpose of hazard mitigation is to reduce the risk by identifying resources, strategies, information for risk reduction. Losses could be minimized by planning and cooperation within the community, municipalities and others.

Options for the current risk adaptation & mitigation are illustrated below:

- ✓ Future risk mapping, zoning and modeling.

- ✓ Develop actionable risk tools and related data bases.
- ✓ Develop best program barriers and assessment opportunities.
- ✓ Improve emergency response capacity as civil defense capacity.
- ✓ Early warning system existence, periodically maintenance checks.
- ✓ Increase society preparedness by training, education and public awareness around threats and hazards.
- ✓ Build climate adaptation knowledge and capacity, adaptation training and capacity building resources.

Ultimately, risk mitigation and adaptation planning enables several actions to reduce loss of life and property and lessening the impact of disasters.

Chapter Five
Conclusions and
Recommendations

Chapter Five

Conclusions and Recommendations

5.1 Overview

This chapter abstracts the thesis results through conclusions. Also, suggests recommendation, and includes suggestions for future studies.

5.2 Conclusions

Based on the information presented in this thesis, the following are the main research conclusions:

- * In recent years, steel structures in WB faced unexpected amount of snow fall which led to collapse in many applications.
- * In WB, many steel structures are not properly designed and constructed to current codes of practice.
- * According to an interview conducted with reviewers in Nablus branch of the Engineering Association, it was concluded that there is a lack of experiences and capabilities on design of steel structures.
- * The climate change has an effect on snow fall in WB which may make current code (Jordanian Code) for computing snow load unsafe under certain circumstances. Thus, modification factors are needed for snow load in the Jordanian code in these circumstances.
- * Risk assessment is an effective tool for identifying the hazards, hazardous events and the consequences for the snow fall hazard.

- * Control tools such as removal of snow and early maintenance of structures can help in avoiding or mitigating snow fall hazard.
- * Adaptation and mitigation options were suggested in order to have the best risk management practices that will reduce the adverse effects.
- * Last but not least, this study has demonstrated the risk assessment technique(s) with steel structures. Linking these two aspects together has contributed a different view towards risk management and the potential risk that may affect such structures.

5.3 Recommendations

Based on the outcome of this research, the following can be recommended:

- ✓ Municipalities, Engineering Associations and local authorities are recommended to employ effective control tools on designs such as a regular checks and maintenance for steel structures. Also, the control measures by the public during, before and after the snow fall are proposed to be implemented.
- ✓ More related data on snow fall events are recommended to be gathered and saved in special units,
- ✓ Strengthening, monitoring and early warning systems are recommended to be implemented to protect current steel structures against extreme weather events.

- ✓ Based on the conclusion that the current design codes may underestimate snow load for certain conditions, it is recommended to establish modification factors for snow loads in these codes.
- ✓ Municipalities, Engineering Associations and other local authorities are recommended to have special awareness of the importance of risk assessment approach in solving problems and making right decisions, particularly, for failure arising from extreme snow fall.
- ✓ Increase the public awareness of the current threats, hazards, and vulnerabilities for snow fall event, thereafter, analysis tools and controls options are recommended to be illustrated for the public by several trainings, applications and developments. Lastly, civil society should be more integrated in the preparedness systems at local level.
- ✓ Increase engineers awareness on their responsibilities especially the site engineers and the importance of their effective supervision of engineering sites.
- ✓ According to the conclusion that there is an insufficient experience on design of steel structures, special steel design courses are recommended to be given to engineers and designers.
- ✓ Improve the emergency response capacity, especially the civil defense and emergency responders which have an important and main role in reducing risks.

- ✓ Based on the conclusion that there is an essential need for hazard mitigation and adaptation plans, governments should be oriented to focus on:
 - * Identifying long-term, broadly-supported strategies for risk reduction.
 - * Constructing a new unit focusing on the risk studies in order to save the records in it, monitor, review and update the assessed risks.
 - * Identifying implementation approaches that focus resources on the greatest threats and consequences; and communicate priorities to potential sources of funding.
 - * Building culture for risk reduction involving government, organizations, businesses and public.

5.4 Future work

The following are some of the key recommendations for further research in this area:

- * The first important topic to focus on is to establish statistical correlation between the climate change events and the increased trend of the snow fall which will assist in developing a modification factor to current codes.
- * A second topic of research is to divide the Palestinian regions into zones based on the risk that may develop due to snow fall, this help to

develop appropriate adaptation and mitigation plans for different regions.

- * The third topic is to accomplish a Quantitative risk analysis to the effect of snow fall on steel structures in the West Bank.
- * Applications of risk assessment on similar events resulting from the global warming such as the extreme wind events are the fourth topic that is suggested.

References

- (PCU) Palestinian Contractors Union. **Construction Sector Profile**.
Palestine: West Bank, PCU; 2003a
- 02ws.co.il, (2016). Snow - Jerusalem Weather Forecast Station. [online]
Available at: [http://www.02ws.co.il/station.php?section=snow.php
&lang=0](http://www.02ws.co.il/station.php?section=snow.php&lang=0) [Accessed 27 Feb. 2016].
- Abu As'ad, Y., Eissa, I., (**Palestinian Meteorological Station-PMS**)
(2015) Personal communication.
- Abu-Sa'da M. (2008). **Climate Change Assessment and Quantification
in Palestine Based on Daily Records**, not published.
- Akintoye, A. and MacLeod, M. (1997). *Risk analysis and management in
construction*. **International journal of project management**, 15(1),
pp.31-38.
- Ali, A. (2000). **Managing Fragile Ecosystems: Combating
Desertification and Drought**, Localizing Agenda 21 in Palestine,
103-118. The Applied Research Institute, Jerusalem.
- ARIJ (Applied Research Institute-Jerusalem) (2008) **Status of the
Environment in the Occupied Palestinian Territory**, Palestine.
- ARIJ (Applied Research Institute-Jerusalem) (2011) **Status of the
Environment in the Occupied Palestinian Territory** (a human
rights - based approach), Palestine.

- ARIJ (Applied Research Institute-Jerusalem) (2012) **Analysis of climate variability and its environmental impacts across the occupied Palestinian territory**, Palestine.
- Aven, T. (2016). *Risk assessment and risk management: Review of recent advances on their foundation*. **European Journal of Operational Research**, 253(1), pp.1-13.
- Azevedo, R., Ensslin, L. and Jungles, A. (2014). **A Review of Risk Management in Construction: Opportunities for Improvement**. **ME**, 05(04), pp.367-383.
- Badreddine, A., Romdhane, T., HajKacem, M. and Amor, N. (2014). *A new multi-objectives approach to implement preventive and protective barriers in bow tie diagram*. **Journal of Loss Prevention in the Process Industries**, 32, pp.238-253.
- Barakat, M. (2013). **Collapse of the physical education building at Birzeit University a case study on forensic engineering**.
- Beer, T. and Foran, B. (2000). **'Management for the future: risk management, future options and scenario analysis'**, In *Risk Management and the Future*, (Beer, T., *Ed.*), Australian Minerals and Energy Environment Foundation, Melbourne, Australia, pp. 39-68.
- Berg, H. (2010). **Risk management: Procedures, methods and experiences**. **RT&A**, 1(2).

Blair T. Foreword by the Prime Minister. **Risk: Improving government's capability to handle risk and uncertainty.** Strategy Unit Report. London, UK:Cabinet Office; 2002.November.

Boswell, M., Greve, A. and Seale, T. (2012). **Local climate action planning.** Washington, DC: Island Press.

Brauch, H., Spring, Ú., Mesjasz, C., Grin, J., Kameri-Mbote, P., chourou, B., Dunay, P. and Birkmann, J. (2011). **Coping with Global Environmental Change, Disasters and Security - Threats, Challenges, Vulnerabilities and Risks.** Hexagon Series on Human and Environmental Security and Peace. New York: Springer.

Carrico, A., Truelove, H., Vandenberg, M. and Dana, D. (2015). *Does learning about climate change adaptation change support for mitigation?*. **Journal of Environmental Psychology**, 41, pp.19-29.

Climate change adaptation strategy and programme of action for the Palestinian authority. (2010). [online] Jerusalem, Palestine: UNDP. Available at: <http://www.undp.ps> [Accessed 29 Dec. 2015].

Cook, J., Nuccitelli, D., Green, S., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P. and Skuce, A. (2013). **Quantifying the consensus on anthropogenic global warming in the scientific literature.** *Environ. Res. Lett.*, 8(2), p.024024.

- Crane, L., Sharp, R., Jose, D., Isaacs, S. and Gantz, G. (2013). **Introduction to Risk Management**. 2nd ed. Extension Risk Management Education and Risk Management Agency.
- Dabbeek, J. (2010). **An Assessment on Disaster Risk Reduction in the Occupied Palestinian Territory**. An - Najah Univ. J. Res. (N. Sc.). 24.
- Dabbeek, J. (2011). **Disaster Risk Reduction: Building the resilience of nations and communities to disasters**, An - Najah Univ. J. Res. (N. Sc.)
- De Marco, A., Jamaluddin Thaheem, M., Grimaldi, G. and Rafele, C. (2012). **A framework methodology for selection of risk analysis techniques in construction projects**.
- Desk study on the environment in the occupied Palestinian territories. (2003). [online] UNEP. Available at: <http://www.unep.org> [Accessed 29 Dec. 2015].
- Di Franco, S. and Salvatori, R. (2015). **Current situation and needs in man-made and natech risks management using Earth Observation techniques**. Remote Sensing Applications: Society and Environment, 1, pp.72-84.
- Djalante, R. and Thomalla, F. (2012). **Disaster risk reduction and climate change adaptation**. Int J of Dis Res in the Bu Env, 3(2), pp.166-180.

- Enríquez-de-Salamanca, Á., Martín-Aranda, R. and Díaz-Sierra, R. (2016). **Consideration of climate change on environmental impact assessment in Spain.** *Environmental Impact Assessment Review*, 57, pp.31-39.
- FEMA, (2014). **Climate Adaptation at FEMA.** Philadelphia.
- Fema.gov. (2016). Hazard Mitigation Planning / *FEMA.gov*. [online] Available at: <http://www.fema.gov/hazard-mitigation-planning> [Accessed 9 Apr. 2016].
- Ferdous, R., Khan, F., Sadiq, R., Amyotte, P. and Veitch, B. (2012). ***Handling and updating uncertain information in bow-tie analysis.*** *Journal of Loss Prevention in the Process Industries*, 25(1), pp.8-19.
- Goerlandt, F. and Reniers, G. (2015). **On the assessment of uncertainty in risk diagrams.** Elsevier.
- Haddad, M. (2012). ***Coping with Global Environmental Change, Disasters and Security: Threats, Challenges, Vulnerabilities and Risks.*** *International Journal of Environmental Studies*, 69(6), pp.1002-1003.
- Hay, J. and Mimura, N. (2010). **The changing nature of extreme weather and climate events: risks to sustainable development.** *Geomatics, Natural Hazards and Risk*, 1(1), pp.3-18.

Hebline. (2013). ذاب الثلج.. وتكشف حجم الدمار الهائل في الخليل. [online] Available

at: <https://hebline.wordpress.com/2013/12/19/%d8%b0%d8%a7%d8%a8-%d8%a7%d9%84%d8%ab%d9%84%d8%ac-%d9%88%d8%aa%d9%83%d8%b4%d9%81-%d8%ad%d8%ac%d9%85-%d8%a7%d9%84%d8%af%d9%85%d8%a7%d8%b1-%d8%a7%d9%84%d9%87%d8%a7%d8%a6%d9%84-%d9%81%d9%8a-%d8%a7/>
[Accessed 15 Aug. 2016].

Hilty, J., Chester, C. and Cross, M. (2012). *Climate and Conservation: Landscape and Seascape Science, Planning, and Action*. 2nd ed. Island Press.

Hochrainer, S. (2006). **Macroeconomic risk management against natural disasters**. Wiesbaden: Deutscher Universitäts-Verlag.

Ighbareyeh, J., Cano-Ortiz, A. and Cano, E. (2014). **Case Study: Analysis of the Physical Factors of Palestinian Bioclimate**. AJCC, 03(02), pp.223-231.

IPCC (Intergovernmental Panel on Climate Change) (2007, a) **Observations: Surface and Atmospheric Climate Change**. In: **Climate Change 2007: The Physical Science Basis**. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2007, b) **Global Climate Projections**. In: **Climate Change 2007: The Physical Science**

Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2007, c) **Special Report on Emissions Scenarios.**

IPCC (Intergovernmental Panel on Climate Change) (2007, d) **Regional Climate Projections.** In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2007,e) **Guidance Notes for Lead Authors of the IPCC Fourth Assessment Report on Addressing Uncertainties,** The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2013), **Climate Change 2013: The Physical Science Basis.** Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC (Intergovernmental Panel on Climate Change) (2014, A): **Climate Change 2014: Impacts, Adaptation, and Vulnerability.** Part A: Global and Sectorial Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC, 2014: Climate Change (2014): **Mitigation of Climate Change.**

Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

IPCC, 2014: Climate Change (2014): **Synthesis Report. Contribution of**

Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

ISO/DIS 31000 (2009). **Risk management - Principles and guidelines on implementation, ISO.**

Jain, S., Goswami, A. and Saraf, A. (2009). *Assessment of Snowmelt Runoff Using Remote Sensing and Effect of Climate Change on Runoff. Water Resour Manage*, 24(9), pp.1763-1777.

Jordanian national building Code, **Loads and forces code.** (2006).

Karkoszka, T. (2015). **Evaluation of the Processes with Application of the Environmental Risk Assessment.** *Procedia Engineering*, 132, pp.146-152.

Khakzad, N., Khan, F. and Amyotte, P. (2012). **Dynamic risk analysis using bow-tie approach.** *Reliability Engineering & System Safety*, 104, pp.36-44

Kouabenan, D., Ngueutsa, R. and Mbaye, S. (2015). **Safety climate, perceived risk, and involvement in safety management.** *Safety Science*, 77, pp.72-79.

- Latham, M. (1994). **Constructing the team**, [London]: [H.M.S.O.].
- Leal Filho, W. (2013). **Climate change and disaster risk management**. Heidelberg: Springer.
- Leeuwen, C. (2007). "**Risk Assessment of Chemicals – 2nd Edition**" European Commission, Joint Research Centre, Ispra, Italy.
- Lelieveld, J., Hadjinicolaou, P., Kostopoulou, E., Chenoweth, J., El Maayar, M., Giannakopoulos, C., Hannides, C., Lange, M., Tanarhte, M., Tyrlis, E. and Xoplaki, E. (2012). **Climate change and impacts in the Eastern Mediterranean and the Middle East**. *Climatic Change*, 114(3-4), pp.667-687.
- Leschka, S. and Packard, H. (2012). **handling risk on high technology programs**.
- Leveson, N. (2015). **A systems approach to risk management through leading safety indicators**. *Reliability Engineering & System Safety*, 136, pp.17-34.
- Lin, L., Nilsson, A., Sjölin, J., Abrahamsson, M. and Tehler, H. (2015). **On the perceived usefulness of risk descriptions for decision-making in disaster risk management**. *Reliability Engineering & System Safety*, 142, pp.48-55.
- Mimi, Z., Mason, M. and Zeitoun, M. (2009). **Climate Change: Impacts, Adaptations and Policy-Making Process: Palestine as a Case Study**.

- Morel, B. and Linkov, I. (2006). **Environmental Security and Environmental Management: The Role of Risk Assessment**. Dordrecht: Springer.
- Müller, R., Wittmer, A. and Drax, C. (2014). **Aviation Risk and Safety Management**. Springer International Publishing.
- Munier, N. (2014). **Risk Management for Engineering Projects: Procedures, Methods and Tools**, Springer International Publishing Switzerland.
- NCA (National climate assessment), (2014). Climate Change Impacts in the United States. [online] Available at: <http://www.globalchange.gov> [Accessed 1 Jan. 2016].
- Ncdc.noaa.gov, (2016). National Centers for Environmental Information (NCEI) formerly known as National Climatic Data Center (NCDC) | NCEI offers access to the most significant archives of oceanic, atmospheric, geophysical and coastal data.. [online] Available at: <http://www.ncdc.noaa.gov> [Accessed 3 Jan. 2016].
- NSC (National standards of Canada), (2002). **Risk Management: Guideline for Decision-Makers**.
- Olson, D. and Wu, D. (2010). *Earthquakes and Risk Management in China*. **Human and Ecological Risk Assessment: An International Journal**, 16(3), pp.478-493.

Pcbs.gov.ps, (2016). Palestinian Central Bureau of Statistics - State of Palestine. [online] Available at: <http://www.pcbs.gov.ps> [Accessed 6 Jan. 2016].

Pe'er G. and Safriel U.(October, 2000) Climate Change: Israel National Report Under The United Nations Framework Convention on Climate Change, Impact, Vulnerability and Adaptation, retrieved November 13, 2008 from http://nasa.proj.ac.il/IsraelResearch/Climate_Change_Israel_National_Report.html

Rausand, M., Risk assessment: Theory, **methods and applications**, Hoboken, NJ: John Wiley & Sons, Inc.,2011.

Rawash, A., El Hagla, K. and Bakr, A. (2014). ***Heuristic Approach for Risk Assessment Modeling: EPCCM Application***; Engineer Procure Construct Contract Management. **Journal of Modern Science and Technology**, 2(1), pp.49-70.

Rodney, E., Ducq, Y., Breysse, D. and Ledoux, Y. (2015). **An integrated management approach of the project and project risks**. IFAC-Papers On Line, 48(3), pp.535-540.

Salem, H. (2011). **Coping with Global Environmental Change, Disasters and Security**. Springer Berlin Heidelberg, pp.421-445.

Saqfelhait, M. (2012). **Construction Contracts in Palestine from Engineering and Legal Perspectives**. MSC, Najah National University.

Shaw, R. (2014). **Disaster Recovery Used or Misused Development Opportunity**, Springer, Japan.

Smartdraw.com. (2016). Fault Tree Diagram Software - Free Analysis Templates Try SmartDraw. [online] Available at: <https://www.smartdraw.com/fault-tree/fault-tree-software.htm> [Accessed 29 Jan. 2016].

Stern, N. (2009). **The economic crisis and the two great challenges of the 21st century.**

Svoboda, M., Fuchs, B., Poulsen, C. and Nothwehr, J. (2015). *The drought risk atlas: Enhancing decision support for drought risk management in the United States.* **Journal of Hydrology**, 526, pp.274-286.

The Orange Book: **Management of Risk - Principles and Concepts.** (2004). London: HM Treasury.

Trenberth, K. (2011). **Changes in precipitation with climate change.** **Climate Research**, 47(1), pp.123-138.

Troccoli, A., Mason, S., Anderson, D. and Harrison, M. (2008). **Seasonal Climate: Forecasting and Managing Risk.** Springer, 82.

UNDP, (2010). **Climate Change Adaptation Strategy and Programme of Action for the Palestinian Authority Report.** Palestine.

- UNDP. (2009), (PAPP) **programme of assistance to the Palestinian people report**, Palestine.
- UNEP, (2003). **Desk Study on the Environment in the Occupied Palestinian Territories report**.
- Uniform building Code (UBC), **Structural design requirements**. (1997).
- Wanner, H., Grosjean, M., Röthlisberger, R. and Xoplaki, E. (2006). *Climate variability, predictability and climate risks: a european perspective*. **Climatic Change**, 79(1-2), pp.1-7.
- Wardekker, J.A. (2011). **Climate change impact assessment and adaptation under uncertainty**. PhD dissertation. Utrecht University, Utrecht.
- Williams, L. (2011). *A (Partial) Introduction to Software Engineering Practices and Methods*. 7th ed.
- Wu, D. (2011). **Modeling risk management in sustainable construction**. Berlin: Springer.
- Wu, K. and Zhang, L. (2014). **Progress in the Development of Environmental Risk Assessment as a Tool for the Decision-Making Process**. **JSSM**, 07(02), pp.131-143.
- Zou, P., Zhang, G. and Wang, J. (2007). *Understanding the key risks in construction projects in China*. **International Journal of Project Management**, 25(6), pp.601-614.

Annexes

Annex (A)

Snow fall depths for Ramallah, Hebron, Nablus and Jerusalem.

In this annex, data for snow depths in different cities are shown in the tables below.

Table A.1: Snow fall details for Ramallah

Year	No. of snowing days	starting from	depth/cm
1997	***	***	***
1998	3	10/1/1998	5--10
1999	***	***	***
2000	3	27/1/2000	15--25
2001	***	***	***
2002	***	***	***
2003	1	25/3/2003	***
2004	1	14/2/2004	8--10
2005	***	***	***
2006	1	27/12/2006	5--4
2007	1	15/3/2007	***
2008	2	30/1/2008	15--20
		19/2/2008	5--10
2009	***	***	***
2010	1	13/12/2010	0--1
2011	***	***	***
2012	1	2/3/2012	1--4
2013	2	9/1/2013	10--20
	1	31/1/2013	***
	3	12/12/2013	25--65
2014	***	***	***
2015	3	7/1/2015	15--25
	2	19/2/2015	2--5

Source: (Abu As'ad, Y., Eissa, I, 2015)

Table A.2: Snow fall details for Hebron

Year	No. of snowing days	starting from	depth/cm
1997	***	***	***
1998	3	10/1/1998	5--10
1999	***	***	***
2000	3	27/1/2000	25--50
2001	***	***	***
2002	***	***	***
2003	1	25/3/2003	0--2
2004	2	14/2/2004	2--5
2005	***	***	***
2006	1	27/12/2006	2--5
2007	1	15/3/2007	0--2
2008	2	29/1/2008	15--20
		19/2/2008	5--10
2009	***	***	***
2010	1	13/12/2010	0--2
2011	***	***	***
2012	2	1/3/2012	15--25
2013	3	9/1/2013	15--25
	3	12/12/2013	25--50
2014	***	***	***
2015	4	7/1/2015	15--25
	3	19/2/2015	5--10

Source: (Abu As'ad, Y., Eissa, I, 2015)

Table A.3: Snow fall details for Nablus

Year	No. of snowing days	starting from	depth/cm
1997	***	***	***
1998	2	11/1/1998	2--5
1999	***	***	***
2000	2	28/1/2000	10--15
2001	***	***	***
2002	***	***	***
2003	1	26/3/2003	0--2
2004	1	15/2/2004	0--2
2005	***	***	***
2006	1	28/12/2006	0--2
2007	***	***	***
2008	1	31/1/2008	0--2
2009	***	***	***
2010	1	12/12/2010	0--2
2011	***	***	***
2012	1	1/3/2012	0--2
2013	3	7/1/2013	0--2
	2	12/12/2013	15--25
2014	***	***	***
2015	3	7/1/2015	15--25
	2	20/2/2015	2--5

Source: (Abu As'ad, Y., Eissa, I, 2015)

Table A.4: Snow fall details for Jerusalem.

Year	Depth/cm
1921	25
1927	20
1928	10
1929	5
1932	20
1936	2
1937	15
1938	2
1939	2
1941	35
1942	20
1943	8
1945	2
1946	8
1948	50
1950	90
1951	20
1953	20
1957	40
1959	20
1962	20
1964	5
1968	35
1969	10
1972	20
1973	40
1974	30
1975	3
1977	20
1980	40
1982	5
1983	60
1989	3
1992	91
1993	5
1998	40

2000	40
2002	5
2003	35
2004	10
2006	5
2008	20
2012	4
2013	65
2015	53

Source: (02ws.co.il, 2016)

Annex (B)**Pictures for snow fall adverse effects.**

This Annex includes different pictures for snow fall adverse effects on several parties which are illustrated below:

1) Royal company:

Royal company suffers from the recent extreme snow fall in winter 2013 in Hebron and had losses about 5 million shekels and the pictures below shows some of the company losses.



Figure B.1 Snow fall adverse effect on Royal company truss



Figure B.2 Snow fall adverse effect on Royal company truss



Figure B.3 Snow fall adverse effect on Royal company truss

2) Shahatet company for building materials:

This company suffers from also the recent extreme snow fall in Winter 2013 in Hebron and had losses about 80 thousand shekels and the pictures below shows some of the company losses.



Figure B.4 Snow fall adverse effect on Shahatet company truss



Figure B.5 Snow fall adverse effect on Shahatet company truss

3) Al Mahabba company:

This company was mentioned during the research and here are some additional pictures for the company losses:



Figure B.6 Snow fall adverse effect on Al Mahabba company truss



Figure B.7 Snow fall adverse effect on Al Mahabba company truss

4) Italian company for marble:

This company was also mentioned in the analysis and these are additional pictures for the truss failure and company losses in materials:



Figure B.8 Snow fall adverse effect on the Italian company truss



Figure B.9 Snow fall adverse effect on the Italian company truss



Figure B.10 Snow fall adverse effect on the Italian company truss

5) Geneva Company:

This company was also mentioned in the analysis and these are additional pictures for the truss failure and company losses in materials:



Figure B.11 Snow fall adverse effect on Geneva company truss



Figure B.12 Snow fall adverse effect on Geneva company truss



Figure B.13 Snow fall adverse effect on Geneva company truss

6) Jamaeen stone cut truss failure:

This example was also mentioned in the analysis and these are additional pictures for the truss failure:



Figure B.14 Snow fall adverse effect on Jamaeen company truss

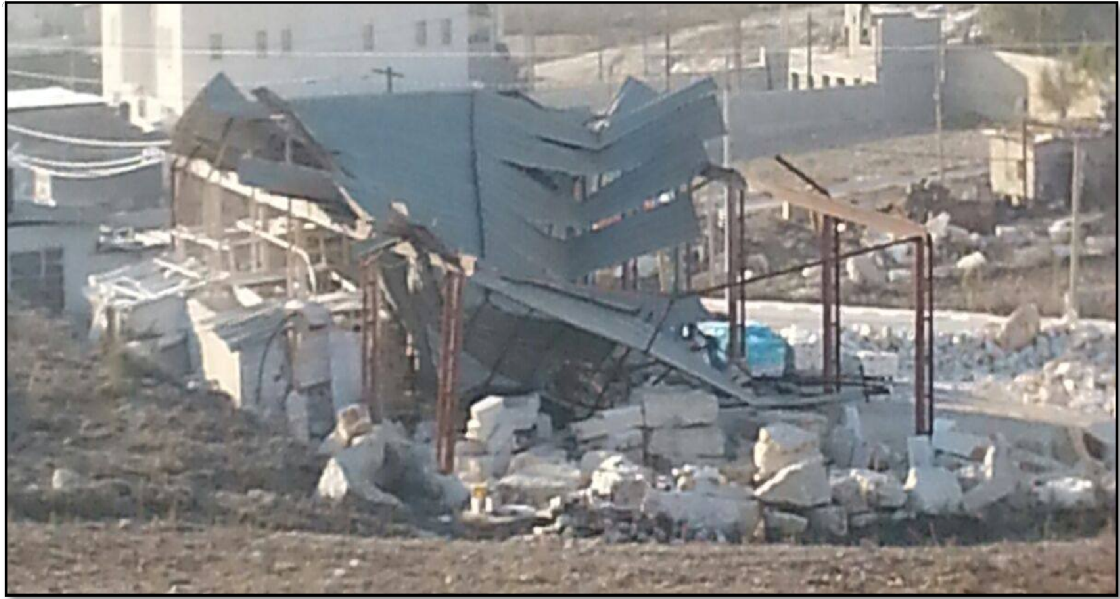


Figure B.15 Snow fall adverse effect on Jamaeen company truss

Annex (C)

List of the “Brainstorming session” attendance

In this Annex, list of attendance during the brainstorming session are listed below in Table (C.1).

Table C.1: List of attendance during the brainstorming session.

Name	Specialty
Dr. Mutasem Baba	Electrical Engineer, Dr at An-Najah National University (ANNU)
Dr. Radwan Al Kilani	Applied Geophysics, Dr. at (ANNU)
Dr. Monther Dweikat	Structural Engineer, Dr. at (ANNU)
Eng. Haitham Sawalha	Building Engineer, Dr. at (ANNU)
Eng. Hussein Abu Zant	Civil Engineer, Dr. at (ANNU)
Dr. Amal Hudhud	Environmental Engineer at Nablus Municipality, Dr. at (ANNU)
Eng. Duaa Al Koni	Chemical Engineer at Nablus Municipality
Eng. Yazan Abu Tahanat	Civil Engineer
Eng. Ibrahim Erman	Structural Engineer, Dr. at (ANNU)
Eng. Rima Nassar	Management Engineer, Eng. at (ANNU)
Eng. Ethar Aqel	Civil Engineer, Master Student at (ANNU)
Eng. Mohamed Jaradat	Civil Engineer
Eng. Ateid Afaneh	Civil Engineer
Dr. Mahmoud Dweikat	Civil and Environmental Engineer, Dr. at (ANNU)
Dr. Mohamed Sama'neh	Civil Engineer, Dr. at (ANNU)
Eng. Rana abu Tayoun	Civil Engineer, Engineering Management Master student at (ANNU)

Name	Specialty
Eng. Darwesh Darwesh	Mechatronics Engineer, Engineering Management Master student at (ANNU)
Eng. Ibrahim Masri	Electrical Engineer
Eng. Ra'fat Hasiba	Civil Engineer
Dr. Isam Jaradaneh	Civil Engineer, Dr. at (ANNU)
Dr. Amer Al Hamouz	Chemical Engineer, Dr. at (ANNU)
Dr. Abdel Fattah Hasan	Environmental Engineer, Dr. at (ANNU)
Dr. Anan Jayousi	Water Engineer, Dr. at (ANNU)
Eng. Mohamed Najjar	Structural Engineer, Master student at (ANNU)
Eng. Anas Fares	Structural Engineer, Master student at (ANNU)
Eng. Mohamad Daraghme	Structural Engineer, Master student at (ANNU)
Eng. Shayma Al Jurf	Structural Engineer, Master student at (ANNU)
Abdallah Al Hroub	Engineering Management Master student at (ANNU)
Alaa Namrouti	Software Developer, Engineering Management Master student at (ANNU)
Eng. Saja Salatneh	Civil Engineer
Eng. Hind Tubaileh	Civil Engineer
Eng. Alaa Shahin	Building Engineer

جامعة النجاح الوطنية
كلية الدراسات العليا

أثر تساقط الثلوج على المنشآت المعدنية في الضفة الغربية - دراسة في تقييم المخاطر

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قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2016م

ب

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الملخص

لقد كان لتغير المناخ على فلسطين في السنوات الماضية الأثر الواضح والذي تسبب في خسائر و أضرار مختلفة في البلاد، كما شهدت الضفة الغربية تزايد كبير في كميات الثلوج و الذي أدى الى خسائر كبيره في اتجاهات مختلفه، مما لفت الانتباه الى ما يمكن ان يؤدي اليه تزايد كميات الثلوج في السنوات المقبلة.

ظهرت الآثار السلبية التي نجمت عن سقوط الثلوج المتكرر وغير المتوقع في عدة اتجاهات كما في قطاعات الزراعة،الاقتصاد، التجاره و المنشآت. كانت التأثيرات على المنشآت المعدنية واضحه جدا للعيان حيث واجهت عدة مشاكل بسبب الأحمال الكثيفة مما أكد على أهمية هذا البحث في دراسة الوضع القائم للتخفيف من الأثر السلبي في السنوات المقبلة والاستجابة الفعالة و الفورية لمثل هذه المخاطر. تعود أهمية هذا البحث الى فهم الوضع الحالي من زيادة سقوط الثلوج على المنشآت المعدنية في الضفة الغربية كحاله خاصه من تغير المناخ، ويكمن ذلك في تقييم أحمال الثلوج الحالية بناء على كودات البناء المستخدمه ومعايير البناء، بالإضافة الى ما يمكن صناع القرار من أخذ الإجراءات الازمة والمناسبة التي تعمل على التقليل من الآثار الناتجة عن زيادة سقوط الثلوج.

تم أيضا تحقيق الأهداف المرجوة في هذا البحث من خلال حسابات احمال الثلوج الواقعه على المنشآت المعدنية بناء على الكود المستخدم، ومن ثم دراسة أثر هذه الأحمال وتكرار تراكمها على اسطح هذه المنشآت و تقدير ما يمكن ان تسببه من مخاطر مستقبلية، وذلك من

خلال تحديد التهديدات، المخاطر والعواقب و اخيرا وليس آخرا، تم اقتراح عدة خيارات في إدارة المخاطر والتي تساعد على التخفيف منها و التكيف معها على المدى الطويل.

تم تحقيق التحليل الانشائي و تحليل المخاطر في هذا البحث، بداية في التحليل الانشائي ثم اثبات وجود مشكله حقيقية تواجه المنشآت المعدنية حاليا، وذلك من خلال اجراء تحليل انشائي في حالتين دراسيتين، الأولى في منشأة معدنية في قرية جماعين والأخرى المتمثلة بمنشأة الشركة الايطالية للرخام في مدينة رام الله. و اثبت التحليل وفق قوانين برنامج الساب 2000 ووفق الكودات المستخدمة ان المنشآت كانت آمنة خلال التحليل ولكنها في الواقع انهارت تحت الأحمال الغير متوقعه، مما اكد على ضرورة إيجاد عوامل معادله للأحمال المستخدمة لضمان أمن المنشآت في السنوات المقبلة تحت اي ظروف. بالإضافة الى اجراء تحليل لمخاطر سقوط الثلوج على المنشآت المعدنية و الذي تمثل في تعريف الخطر، اسبابه و عواقبه و ذلك باستخدام مودل ال BOW tie و نظام ال Matrices خلال التحليل، ومن ثم اقتراح عدة تدابير في تقييم و ضبط الخطر، و المتمثل في توصيات ازالة الثلوج للمساعدة على منع تراكمها و متابعة صيانة المنشآت.

أخيرا، تم اقتراح خيارات لإدارة الخطر والتحكم به من أجل التخفيف والتكيف معه ومن الامثلة على ذلك، من خلال رفع الوعي العام و جاهزيته للتصدي لمثل هذه المخاطر والمتمثل بتكثيف التدريب و التعليم حول التهديدات والمخاطر المتوقعه، أيضا من خلال تخصيص و تقسيم المدن المعرضة أكثر من غيرها للخطر، بالإضافة الى تحسين القدره على الإستجابة في حالات الطوارئ و المتمثلة بشكل أساسي في جاهزية الدفاع المدني مما يساعد على تخفيف الآثار السلبية التي ممكن ان تتجم عن مثل هذه المخاطر.

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