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Influence of Climate Change on the Lifecycle of Construction Projects at Gaza Strip

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Abstract: ***There is a high confidence based on scientific evidence that climate is changing over time. Now climate change is considered as one of the challenges facing the construction industry. As no project is risk free and climate change has a strong impact on the different phases of the construction project lifecycle. This research aimed at providing a platform of knowledge for the construction management practitioners about the impacts of climate change on the construction projects lifecycle, identify the most dangerous climate change factors on the construction project lifecycle, and identify the most affected phase by climate change factors through the construction projects lifecycle. The study depended on the opinions of civil engineers who have worked in the construction projects field among the reality of Gaza Strip. Questionnaire tool was adopted as the main research methodology in order to achieve the desired objectives. The questionnaire included 127 factors in order to obtain responses from 88 construction practitioners out of 98 representing 89.79% response rate about the influence of climate change on the generic lifecycle of construction projects. The results deduced that the most significant influence on the construction project lifecycle was related to the extreme weather events, rainfall change, and temperature change respectively. There was a general agreement between the respondents that the most affected phase by temperature, rainfall, and extreme weather events is the execution phase. The results also asserted with a high responses scale on the need to alternative procedures and clear strategies in order to face the climate change within construction industry.***

Keywords: Climate Change, Construction, Temperature, Rainfall, Extreme weather events

I. BACKGROUND

Climate change is now significant and a scientifically established fact so it has become a serious and worldwide concern [1].

The Palestinian territory, as group of the Eastern Mediterranean, is subject to many serious climate changes such as annual rainfall, mean temperature, and extreme weather events [2]. The concept of climate change has emerged in the most recent Palestinian Reform and Development Plan, which outlines the government's key budgetary priorities. Environment Quality Authority (EQA) is the main Palestinian governmental body responsible for environmental protection [3].

Climate change is on the forefront of construction industry discussions because of the eloquent consequences that affect the projects lifecycle, so the construction sector has to be more efficacious and tackle challenges [4]. Excellence in project management is achieved through a structured process that includes a series of phases that a project passes through from its initiation to its closure or so-called project management lifecycle [5]. There are four basic project phases otherwise regarded as initiation phase, planning, and design phase, execution phase and at the end of cycle, the closing phase shows that value is now being lost, and it is no longer profitable to continue the process. Therefore, the project cycle is closed [6].

Climate change increases the risks associated with embarking on construction project cycle [7]. Climate change can affect construction sector directly through weather and climate, but can also generate indirect impacts such as site programming, delay, extra expense, laborers safety, material cost, and delivery [8]. There is overwhelming evidence that climate change has created threats. The project management practitioners need to suit their experience and expertise to understand better the influence that climate change could have on the way they secure their projects in the future. They should know how do they minimize the impacts of climate change on their profession and continue to develop and grow as successful businesses and yet continue to meet the needs of their clients [9].

The literature review revealed a lack of research work undertaken on the influence of climate change on the projects lifecycle in Gaza Strip construction industry. This deficiency is a major contributor to the development of this current research rational, which focuses on management sector, and how this sector in turn, can deal with the climate change. This research study is concerned with the climate change and its impacts on the lifecycle of construction projects at Gaza Strip. The aim of this research is to provide a platform of knowledge for the construction management practitioners about the impacts of climate change on the construction projects lifecycle. The primary objectives of this research are: To identify the influence of temperature change, rainfall change, and extreme weather events on the construction project

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lifecycle, and to clarify the suitable procedures to face the influence of climate change within construction industry in order to assist the construction professionals to benchmark their efforts with different phases together.

A. Climate Change and Project Lifecycle

All trends prove that there is a changing in the global climate [10]. Climate change has a strong impact on the different phases of the project lifecycle. The management practitioners should be researching localized risks of climate change and preparing their works for the predicted hazards which may include increasing temperature, rainfall, wind, mean sea level ...etc [11]. At the planning level it is argued that successful adaptation policy might effectively decouple risks. Risk management plays a large group in getting successful project completion, [12]. The effect of climate change as it poses a risk to projects it must be assessed and managed through the projects lifecycle [13]. In order to limit the risks caused by the variations in sea level, extreme weather events or the rainfall, a responding strategy is necessary and assessment methodology represents a high priority [14].

B. Climate Change Consequences on Project Design and Planning

The climate change poses risks to planning and design of construction projects including construction site choice, delay to construction program completion, structural damage and the techniques of materials and buildings. All of this leads to excessive cost and unexpected expenses, so the construction professionals should apply more considerations and take the climate change into accounts [15].

Climate change affects the pricing design strategies and leads to take into account differences such as building age, construction, and loss mitigation efforts, which affect likely losses during extreme weather events due to changes in building codes over time [16]. A major challenge that faces designers and planners is to predict with confidence the extent of vulnerability of construction elements to climate change throughout an element's lifetime [17].

C. Climate Change Consequences on Construction Workforce

The outdoor workers in this sector are subject to higher risk from increased direct-heat stress, dehydration and potentially skin cancer, as well as heavy rainfall. The changing climate could bring some opportunities for the construction industry, with a demand for new materials and adaptive buildings [18]. Higher temperatures may restrict the work time hours. Impacts of climate on health and safety of the workforce may necessitate taking precautions for workers, e.g., construction workers during heat waves. Increased illness in the population more broadly may affect work attendance or health care costs [16]. In lower temperatures, workers must wear extra clothing that is often heavy and bulky. Bulky clothing can restrict movement and increase the risk of accidents [19].

D. Climate Change Consequences on Equipment and Materials

Dusty conditions may lead to problems for equipment; the filters on vehicles and machinery both inside and outside should be checked and changed regularly to prevent premature breakdowns. Further, cold temperature make a problem with water cooled engines; like people equipment can act a little sluggish when it is cold. Cold lubricants are not effective and operating equipment with inadequate lubrication can cause accelerated wear of moving groups [19].

Most materials are susceptible to water, from concrete and mortar to paint because their strength and workability are affected by additional water. Material with high water content and those that depend on hydration or evaporation may not cure properly at low temperature and consequently result in attaining lower strengths [20]. Moisture can penetrate brick through capillary action and the action of wind-driven rain, moisture can reach the interior and condense on interior walls, this can lead to mould growth, deterioration of finishes and potential health problems for occupants [21]. The paintings works are affected by climate change both performance and application of surface finishes [19].

E. Climate Change Consequences on Construction Process

The construction phase is highly weather dependent, which influence the site work conditions, construction processes, and worker comfort. The effects of climate change cause slope instability and damage to the building fabric [15].

Temperature is a critical issue in construction process. Concrete is one of the most widely used materials and relies on setting and curing within certain temperature parameters [20]. The optimum temperature to cure concrete is 23℃, which gives 80-100% greater strength than concrete, which has not been properly cured [15].

Structures are designed to have at least a minimum resistance to the loads that act on the structure and the climate change has consequences in structure design process. The climatic actions on buildings such as temperature have an intensity which vary through the lifetime of structure and will exceed the assumed value in the design. They also argued that differences in temperature cause structures to expand and become smaller [23].

II. Climate change in Gaza Strip

The Palestinian territory is subject to many serious climate changes [24]. Gaza Strip as group of the Palestinian territories is also affected by climate elements such as temperature, rainfall, wind, precipitation, mean sea level, humidity and their fluctuations [25]. Changes in climate

already detected in the region may be instructive in assessing the exposure to those predicted changes. In the following, a review of information on such changes is presented.

A. Temperature

Records of Gaza Strip temperature in the three decades between 1976 and 2006 showed a trend towards raising temperature in both the minimum and maximum averages, this increase was clear in the minimum temperature averages more than the maximum temperature averages. The trend of minimum averages of the three-interval time (1976-1985, 1986-1995, and 1996-2006) accounted for 15.91, 16.70, and 17.64℃, respectively. In general, Gaza Strip temperatures analysis between 1976 and 2006 showed a rising trend; in the second decade between 1986 to 1995 comparing to the first decade between 1976 to 1985, the average temperatures showed increase by 0.79℃ and 0.29℃ for the minimum and maximum temperatures, respectively. In the third decade between 1996 to 2006 comparing to the second decade between 1986 and 1995, the average temperatures showed increase by 0.94 and 0.26℃ for the minimum and maximum temperatures, respectively. Overall, temperatures increase in Gaza Strip within the past thirty years was clear by around 1.73 degree in the average minimum temperatures, and around 0.55 degree in the average maximum temperatures of the Gaza Strip [26].

B. Rainfall

Rainfall records for Palestinian date back to 1845 where measurements were first taken at the Scottish hospital in Jerusalem. Rainfall records for Palestine reveal that the climate change is a real phenomenon. The calculated trend line indicates that rainfall is decreasing at an average rate of 1.4mm per year. This relates to a reduction of 233.8 mm in total annual rainfall over 167-year period from 1845 to 2012. Where the highest recorded rainfall was 1,091mm during the 1877-1878 rainy season and the lowest recorded rainfall was 206.3mm during the 1959-1960 rainy season. The rainfall in Gaza Strip follows a similar trend, which is decreasing [27].

Figure 1 illustrates observed total annual rainfall in the Gaza Strip for the rain seasons 2001-2011 which follows a deceasing trend [27].

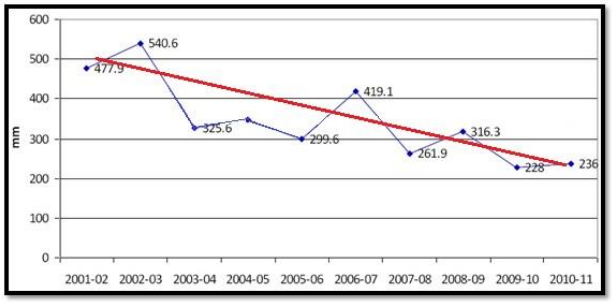

FIGURE I
Total annual rainfall in Gaza Strip for rain seasons (2001-2011), source: adapted from [25]

C. Extreme weather events

For the Palestinian Territory, high precipitating and extreme weather events are leading to significant effects groupicularly in contexts in which the regional water management infrastructure lacks resilience. Such was the case of 36-hours of heavy precipitation on 27-29 October 2008 in the Gaza Strip, where storm water and wastewater drainage systems were overwhelmed by an unusually intense and caused disruptive and destructive impacts [28].

III. Methodology

This research is designed to target all construction management staff in Gaza Strip including "construction managers, designers, project engineers, and site engineers." According to the Engineering Association there are 3695 civil engineers registering in the association until 31/05/2013. The methodology adopted for carrying out this research is quantitative approach. Quantitative approach was employed to serve the objectives of this research. The questionnaire has been prepared by researcher with the use of previous studies related to the subject of this research, where this study is an extension of past researches. This research is linked to many researchers including [17], [29], [15], [30], [19], [8], [20], [31] Who discussed the impacts of climate change from independent fields in construction such as materials, workforce, equipments, adaptation, etc. In particular, this research is attempt to build clear and integrated relation which focuses on the climate change impacts through the various phases of construction projects including the different project activities for the purpose of providing a useful tool in assessing the relationship between climate change and construction industry and to improve adaptive way to face the expected results.The quantitative data was collected using a questionnaire tool where designed based on the related studies "literature" that are in line with the research title in addition to some information that was gained through unstructured interviews with professionals in the field of management practice. A pilot study was conducted to provide a trial run for the questionnaire, which involves testing the wordings of questions, identifying ambiguous questions, testing the techniques that used to collect data. The collected raw data was sorted, edited, coded, and entered into computer software. A software program; Statistical Package for the Social Sciences (SPSS) was used. Through applying the SPSS program, many tests were applied to achieve the purpose of analysis.

This research is limited to construction projects and also the civil engineers who are registered in the Engineers Association and working as designers, site engineers, office engineers, construction managers and other positions.

Five-point Likert scale has been used. Five point Likert a scale was be labeled as follows: Strongly disagree, Disagree, Neutral, Agree, Strongly agree.

The questionnaire was divided to two types of questions; agreement scale questions and multiple choice question. One hundred and twenty seven factors were

distributed over the group one "Background and assessment information", group two "Influence of temperature on the project lifecycle", group three "Influence of rainfall on the project lifecycle", group four "Influence of extreme weather events on the project lifecycle" and group five "The required procedures to face the climate change within construction industry".

The questionnaire was distributed in two ways: Electronic way via Email, Facebook and other means of communications and printed and hand delivered way. To overcome the risk of not responding, the questionnaire was distributed to a number higher than the calculated sample size. Fortunately, the response rate was very high which the returned number of respondents was 88 out of 98 with response rate equal to 89.79%.

IV. Results and Discussion

Table 1 illustrates that the bachelor degree respondents are 79.55 %, and the master degree respondents are 20.45 %. This gives high confidence in the respondent's evaluation.

TABLE I
PROFILE OF RESPONDENTS

Assessment Information	Frequency	Percentage
Education Level		
Diploma	0	00.00 %
Bachelor	70	79.55 %
Master	18	20.45 %
Ph.D.	0	00.00 %
Total	88	100%
Work position		
Designer	5	05.68 %
Site engineer	57	64.77 %
Office engineer	24	27.27 %
Construction manager	2	02.27 %
Other	0	00.00%
Total	88	100 %
Years of experience		
1-5	8	09.09 %
6-10	19	21.59 %
11-15	58	65.90 %
>15	3	03.40 %
Total	88	100 %
Size of the executed construction projects for the last 3 years		
< 0.5 million $	0	00.00%
0.5-1 million $	2	02.27%
1-3 millions $	4	04.55%
>3 millions $	82	93.18%
Total	88	100%

The respondent who works as designers are 5.68 %, site engineers are 64.77 %, office engineers are 27.27 % and the construction managers are 2.27 %. The varieties of work positions enrich the research with different views and responses. For the years of experience, the majority of respondent (65.90 %) are between 11-15 years. The majority of respondents have experience, which adds some values to the results.

The results show that 93.18 % are related to the executed projects with more than 3 millions $ size. This indicates the size of construction works at Gaza Strip for the last three years are of medium size.

A. Temperature Change

From Table 2 it can be grasped that most affected phase by temperature change is the execution phase with ($\bar{X}$ = 3.74). These results indicate that the temperature change is most sensible in the execution phase, which reflects that the project activities are more directly exposed to temperature change in this phase than others.

The most significant factor related to the influence of temperature on the initiation phase was about the choice of site location with ($\bar{X}$ = 4.09). This factor makes a conception cloud in the process of project site selection in order to be suitable with project type and its services. The site location can include the sides of site whether eastern, western, northern and southern, or to be close to the sea or away. The temperature change may also affect the soil temperature and thus the amount of water in the soil, which considered as an important factor.

The highest ranked factor related to the influence of temperature on the planning and design phase was about increasing the minimum required standards of building codes with ($\bar{X}$ = 3.87). Frankly, the climatic events lead to loads on buildings, thus the climate change will have effects on the design loads. The temperature of the inner environment and the outer environment are assumed not to change when dealing with the extreme loads on structure. In the same time it's postulated that there is a temperature change, so a difference in temperature will be varied, this indicates that more care should be given when drafting new design codes due to the larger concrete expansions. This issue was supported by [21].

TABLE II
INFLUENCE OF TEMPERATURE ON THE PROJECT LIFECYCLE

	Section A: Influence of Temperature on the Initiation Phase	Mean	Rank
1	Have high impacts on defining project objectives	2.61	5
2	Play a vital role in including or excluding of some project's groups	3.19	3
3	Influence the hiring and recruiting of a suitable project team	3.09	4
4	Influence the identification of project needs	3.70	2
5	Influence the organization structure of project	2.30	7
6	Affect the elevation and topography of the site	2.52	6
7	Affect the choice of site location	4.09	1
	Overall Mean of Section A	**3.07**	**3**
	Section B: Influence of Temperature on the Planning and Design Phase	Mean	Rank
1	Pose risks to planning and design methods	3.20	7
2	Effect on the selection of construction materials	3.85	2
3	Cause structural damages which lead to excessive cost	3.79	4
4	Make planning of structures difficult	2.69	9
5	Have a vital role in the pricing design strategies	3.40	6
6	Lead to take into account differences such as building age, construction and loss mitigation efforts	3.80	3
7	Bring opportunities for the construction industry	3.68	5

	with a demand for new materials and adaptive building methods		
8	Play a role to increase the minimum required standards of building codes	3.87	1
9	Cause high volumes of claims for insurance companies	3.03	8
	Overall Mean of Section B	**3.48**	**2**
Section C: Influence of Temperature on the Execution Phase		Mean	Rank
1	Lead to unsafe work conditions and leaves the workers at higher risk	3.65	6
2	Lead to problems for equipment and preclude heavy machinery from working efficiently	3.47	8
3	Impact strength and workability of construction materials	3.81	4
4	Affect performance and application of painting finishes	3.78	5
5	Affect the rate of concrete hardening	4.09	3
6	Affect the process of concrete casting and workability	4.15	2
7	Affect the process of concrete curing	4.64	1
8	Make a reduction in bond strength between the mortar and bricks	3.56	7
9	Cause delay to construction program completion	3.02	10
10	Delay transport and delivery of materials causing more cost	3.26	9
	Overall Mean of Section C	**3.74**	**1**
Section D: Influence of Temperature on the Closing Phase		Mean	Rank
1	Lead to unfamiliar conditions after work completion	3.21	2
2	Cause delay in handing over to the clients	2.80	7
3	Restrict the documentation and reporting at final stage	1.98	8
4	Cause after completion unexpected problems and defects in the structure	3.04	6
5	Require additional maintenance works after completion of project activities	3.20	4
6	Cause at the final stage additional resources and materials which lead to unexpected expenses	3.21	2
7	Play a vital role at the last stage which may generate a high rate of claims between groupies	3.23	1
8	Cause disputes between contractors, subcontractors , suppliers	3.17	5
	Overall Mean of Section D	**2.98**	**4**

In the executions phase, the most important factors were about the process of concrete curing, affect the process of concrete casting and workability, affect the rate of concrete hardening, impact strength and workability of construction materials and affect performance and application of painting finishes. It can be deduced that the change in temperature is a critical issue in construction process. Concrete as one of the most widely used materials in construction projects field relies on setting and curing, casting and hardening within a certain temperature. Thus, the temperature change affects the curing process directly due to the relation between water and temperature. Many studies confirm this issue and its effects such as [22], [15], [19] and [20]. In addition, the temperature affects the painting works and safety of work.

The top significant factor related to the influence of temperature on the closing phase was about the generating a high rate of claims between groups at the last stage with ($\bar{X}$ = 3.23). This result indicates that the change in temperature can lead to unusual weather, which may affect the job progress days. Contractor as a main group in the project can obtain a time extension if he able to show that conditions varied from the normal case and prevented him from keeping the performance schedule. Sussman and Freed [16] asserted that the most significant risk arising from the physical effects of climate change faces insurance industry is the high volumes of claims.

B. Rainfall Influence

From Table 3 it can be shown that the most effected phase by rainfall change is the execution phase then the planning and design phase with ($\bar{X}$ = 4,06), ($\bar{X}$ = 4.03) respectively. The rainfall change is most sensible in the execution phase, which reflects that the project activities are more directly exposed to rainfall change in this phase than others are. The results also show the extent of rainfall change influence on the planning and design phase, which reflect the risk that climate change, can pose to planning and design.

The top significant factor related to the influence of rainfall on the initiation phase was about the choice of site location with ($\bar{X}$ = 4.28). This result agrees with the results from the temperature change section. This makes a confirmation on the influence of various factors of climate change on the process of site choice. It shows how the site selection can be a good tool to adapt to climate change effects in attempt to reduce the sensible impacts. Rainfall change can affect the soil classification and thus affect the structure of construction projects.

TABLE I II

INFLUENCE OF RAINFALL ON THE PROJECT LIFECYCLE

Section A: Influence of Rainfall on the Initiation Phase		Mean	Rank
1	Have high impacts on defining project objectives	3.42	5
2	Play a vital role in including or excluding of some project's groups	4.05	2
3	Influence the hiring and recruiting of a suitable project team	2.56	7
4	Influence the identification of project needs	3.60	4
5	Influence the organization structure of project	3.18	6
6	Affect the elevation and topography of the site	4.01	3
7	Affect the choice of site location	4.28	1
	Overall Mean of Section A	**3.58**	**4**
Section B: Influence of Rainfall on the Planning and Design Phase		Mean	Rank
1	Pose risks to planning and design methods	3.78	7
2	Effect on the selection of construction materials	4.14	4
3	Cause structural damages which lead to excessive cost	4.48	1
4	Make planning of structures difficult	3.50	9
5	Have a vital role in the pricing design strategies	3.73	8
6	Lead to take into account differences such as building age, construction and loss mitigation efforts	4.28	3
7	Bring opportunities for the construction industry with a demand for new materials and adaptive building methods	3.84	6
8	Play a role to increase the minimum required standards of building codes	4.12	5
9	Cause high volumes of claims for insurance companies	4.42	2

	Overall Mean of Section B	**4.03**	**2**
Section C: Influence of Rainfall on the Execution Phase		Mean	Rank
1	Lead to unsafe work conditions and leaves the workers at higher risk	4.29	3
2	Lead to problems for equipment and preclude heavy machinery from working efficiently	3.72	9
3	Impact strength and workability of construction materials	3.64	10
4	Affect performance and application of painting finishes	3.90	8
5	Make excavation and earthwork more difficult	4.34	2
6	Affect the process of concrete casting and workability	4.23	4
7	Affect the process of concrete curing	4.63	1
8	Make a reduction in bond strength between the mortar and bricks	3.51	11
9	Affect upon the use of tower, cranes and scaffoldings	4.07	7
10	Cause delay to construction program completion	4.11	6
11	Delay transport and delivery of materials causing more cost	4.17	5
	Overall Mean of Section C	**4.06**	**1**
Section D: Influence of Rainfall on the Closing Phase		Mean	Rank
1	Lead to unfamiliar conditions after work completion	3.31	7
2	Cause delay in handing over to the clients	4.39	1
3	Rainfall may restrict the documentation and reporting at final stage	2.43	8
4	Cause after completion unexpected problems and defects in the structure	3.81	5
5	Require additional maintenance works after completion of project activities	4.32	2
6	Cause at the final stage additional resources and materials which lead to unexpected expenses	3.81	5
7	Play a vital role at the last stage which may generate a high rate of claims between groupies	4.03	3
8	Rainfall may cause disputes and litigation between contractors, subcontractors and suppliers	3.94	4
	Overall Mean of Section D	**3.76**	**3**

The intensity which may cause structural damages and lead to excessive cost with ($\bar{X}$ = 4.48) was the most important factor related to the influence of rainfall on the planning and design phase. The change of rainfall can be a disruptive element which affect the project progress and lead to unexpected expenses, so it should be applied more considerations to avoid any critical consequences. This issue was agreed with reference [15].

The significant influence of rainfall on the execution phase was about the concrete curing with ($\bar{X}$ = 4.63). This result is the same as temperature change section. The result asserts that concrete, as one of the susceptible materials to water is one of the most effected elements by climate change whether by storing, casting, or curing.

In the closing phase, the high significant factor related to the influence of rainfall was about the delay of the handing over to the clients with ($\bar{X}$ = 4.39). This is a normal reflection to the effects of rainfall change. Rainfall change can affect the progress of construction projects and cause structural damage so delay can be a future event. This issue agrees with reference [15].

C. EXTREME WEATHER EVENTS

From Table 4 it can be grasped that the top significance phase related to influence of extreme weather events is the execution phase then the closing phase, ($\bar{X}$ = 4,38), ($\bar{X}$ = 4.21), ($\bar{X}$ = 4.07).

The extreme weather events is most sensible in the execution phase which reflects that the project activities are more directly exposed to extreme weather events in this phase than others. This result agrees with the results from the influence of temperature and rainfall factors for this phase. The results also show high means for the other lifecycle phases which mean that extreme weather events hit strongly the lifecycle of construction projects.

Including or excluding of some project's groups with ($\bar{X}$ = 4.13) is the highest factor related to the influence of extreme weather events on the initiation phase. The extreme weather events can play a major role in the initiation phase, which affect the decision making about including or excluding some groups of the project in order to adapt or mitigate the effects of extreme weather events.

The most significant factor related to the influence of extreme weather events on the planning and design phase was about generating a high volumes of claims for insurance companies with ($\bar{X}$ = 4.73). The risk of extreme weather events is a significant factor of climate change,

TABLE IV
INFLUENCE OF EXTREME WEATHER EVENTS ON THE PROJECT LIFECYCLE

Section A: Influence of Extreme Weather Events (EWE) on the Initiation Phase		Mean	Rank
1	Have high impacts on defining project objectives	2.65	6
2	Play a vital role in including or excluding of some project's groups	4.13	1
3	Influence the hiring and recruiting of a suitable project team	2.97	5
4	Influence the identification of project needs	3.42	4
5	Influence the organization structure of project	2.55	7
6	Affect the elevation and topography of the site	3.90	2
7	Affect the choice of site location	3.57	3
	Overall Mean of Section A	**3.31**	**4**
Section B: Influence of Extreme Weather Events on the Planning and Design Phase		Mean	Rank
1	Pose risks to planning and design methods	4.06	5
2	Effect on the selection of construction materials	3.19	9
3	Cause structural damages which lead to excessive cost	4.65	2
4	Make planning of structures difficult	3.63	8
5	Have a vital role in the pricing design strategies	3.76	7
6	Lead to take into account differences such as building age, construction and loss mitigation efforts	4.15	4
7	Bring opportunities for the construction industry with a demand for new materials and adaptive building methods	3.79	6
8	Play a role to increase the minimum required standards of building codes	4.62	3
9	Cause high volumes of claims for insurance companies	4.73	1
	Overall Mean of Section B	**4.07**	**3**
Section C: Influence of Extreme Weather Events on the Execution Phase		Mean	Rank
1	Lead to unsafe work conditions and leaves the workers at higher risk	4.61	4
2	Lead to problems for equipment and preclude heavy machinery from working efficiently	4.11	8
3	Impact strength and workability of construction	3.86	11

	materials		
4	Affect performance and application of painting finishes	3.97	10
5	Make excavation and earthwork more difficult	4.57	5
6	Affect the process of concrete casting and workability	4.62	3
7	Affect the process of concrete curing	4.75	1
8	Make a reduction in bond strength between the mortar and bricks	4.05	9
9	Affect upon the use of tower, cranes and scaffoldings	4.64	2
10	Cause delay to construction program completion	4.55	6
11	Delay transport and delivery of materials causing more cost	4.42	7
	Overall Mean of Section C	**4.38**	**1**
Section D: Influence of Extreme Weather Events on the Closing Phase		Mean	Rank
1	Lead to unfamiliar conditions after work completion	4.03	7
2	Cause delay in handing over to the clients	4.65	1
3	EWE may restrict the documentation and reporting at final stage	2.72	8
4	Cause after completion unexpected problems and defects in the structure	4.45	3
5	Require additional maintenance works after completion of project activities	4.42	4
6	Cause at the final stage additional resources and materials which lead to unexpected expenses	4.35	6
7	Play a vital role at the last stage which may generate a high rate of claims between groupies	4.64	2
8	EWE may cause disputes and litigation between contractors, subcontractors and suppliers	4.39	5
	Overall Mean of Section D	**4.21**	**2**

which needs more care and consideration. Sussman and Freed [14] asserted that insurance industry faces a significant risk related to the high volumes of claims.

The process of concrete curing with ($\bar{X}$ = 4.75) is the top significant factor related to the influence of extreme weather events on the execution phase. This confirms that concrete is one of the most effected elements by climate change whether by temperature, rainfall or extreme weather events.

In closing phase, the most significant factor related to the influence of extreme weather events was about delay of the handing over to the clients with ($\bar{X}$ = 4.65). This result agrees with the result of rainfall section with reflects the correlation between the rainfall change effects and extreme weather events.

D. TOP INFLUENCE FACTORS

TABLE V
THE RANK OF THE THREE GROUPS

Group	Mean	Rank
Influence of extreme weather events on the project lifecycle	4.05	1
Influence of rainfall change on the project lifecycle	3.89	2
Influence of temperature change on the project lifecycle	3.36	3

Table 5 deduced that the influence of extreme weather events on the project lifecycle is the top group then the influence of rainfall change and the influence of temperature change in the last level with ($\bar{X}$ = 4.05), ($\bar{X}$ = 3.89) and ($\bar{X}$ = 3.36) respectively. The effects that temperature may cause the rainfall can do with higher range and the effects that rainfall may cause the extreme weather events can do with higher range so the rank reflects the level of risk due to each factor of climate change.

From Table 6 it can be concluded that the values of mean and resulted ranks of respondents were due to the climate change factors more than the lifecycle phases. This confirms that the climate change factors play the major role in the orientation of responses for the significant factors regardless the phase.

TABLE VI
THE IMPORTANCE OF ALL SECTIONS OVER THE THREE GROUPS

Section	Factor	Phase	Mean	Rank
Influence of extreme weather events on the execution phase	Extreme weather	Execution	4.38	1
Influence of extreme weather events on the closing	Extreme weather	Closing	4.21	2
Influence of extreme weather events on the planning and design phase	Extreme weather	Planning	4.07	3
Influence of rainfall on the execution phase	Rainfall	Execution	4.06	4
Influence of rainfall on the planning and design phase	Rainfall	Planning	4.03	5
Influence of rainfall on the closing phase	Rainfall	Closing	3.76	6
Influence of temperature on the execution phase	Temp.	Execution	3.74	7
Influence of rainfall on the initiation phase	Rainfall	Initiation	3.58	8
Influence of temperature on the planning and design phase	Temp.	Planning	3.48	9
Influence of extreme weather events on the initiation phase	Extreme weather	Initiation	3.31	10
Influence of temperature on the initiation phase	Temp.	Initiation	3.07	11
Influence of temperature on the closing phase	Temp.	Closing	2.98	12

E. PROCEDURES TO FACE THE CLIMATE CHANGE

The most effective managerial procedures is the implementation of monitoring and reporting system for climate change with ($\bar{X}$ = 4.53) which indicate the importance of archives data availability and reflects the responsibility of management to keep acceptable level of reports as a feedback. The second factor was about the documented site plan to deal with climate change in the organization with ($\bar{X}$ = 4.44) which indicate the role of organization and commitment to provide ready and flexible steps in site in attempt to adapt or mitigate any risk consequences. The third factor was about the concern of

organization about the past records of climate change data with ($\bar{X}$ = 4.40) which confirm on doing the first factor.

The required procedures to face temperature were investigated. The high important factor was using of admixture as a good way to avoid the effects of temperature on the concrete curing, then the application of insulation systems such as roofing paints and glazing as an effective tool to reduce the rate of temperature increasing effects on buildings with ($\bar{X}$ = 4.57), ($\bar{X}$ = 4.51) respectively. The results indicate the significance of applying these strategies in the same time. This can be grasped from close values of means. The responsible bodies must bear in mind the applying of the mentioned strategies on the all aspects whether on the raw materials, used materials or on the existing buildings in order to adapt to the risk of increased temperature.

TABLE VII
REQUIRED PROCEDURES TO FACE THE CLIMATE CHANGE

	Section A: Managerial Procedures	Mean	Rank
1	Implement monitoring and reporting for climate change should be required to face climate change	4.53	1
2	The organization must have a documented site plan to deal with climate change	4.44	2
3	A training program can be very important to face climate change	3.69	8
4	The organization should take into account the experience and knowledge of staff about climate change in the recruitment process	4.30	4
5	The organization must be concerned about the past records of climate change data	4.40	3
6	The organization must have communication channels to use when dealing with climate change aspects	4.12	6
7	There should be a cooperation system between different levels of organization to handle climate change issue	4.15	5
8	The organization must recruit formal representatives related to climate change discussions and meetings	3.75	7
	Section B: Procedures for Temperature	Mean	Rank
1	Insulation such as roofing paints and glazing may be effective to reduce the rate of temperature increasing effects on buildings	4.51	2
2	Shading can be useful for surfaces to avoid transfer of temperature increase through buildings	4.10	4
3	Shading of construction materials can be significant to resist the risk of increasing temperature	3.73	5
4	Admixtures can be a good way to avoid the effects of temperature on the concrete curing	4.57	1
5	Using of double walling system may be significant tool to handle with temperature changes	4.15	3
	Section C: Procedures for Rainfall	Mean	Rank
1	Design more appropriate window protection may be required to resist rainfall impacts	3.84	4
2	Using of insulation materials can resist the effects of rainfall on building	4.09	3
3	Using of collection systems with greater capacity may solve the effects of rainfall changes that cause shortened rainy days	4.21	1
4	Ensuring well maintained for roofs and drainage systems must be done to avoid side effects of rainfall changes	4.12	2
5	Diverting rainwater from buildings to street tree rout zones is most important to keep water and avoid effects on drainage systems of buildings	3.14	5
	Section D: Procedures for Extreme Weather Events	Mean	Rank
1	External claddings and glazing may be most important to reduce the effects of extreme weather events on buildings	4.06	2
2	Improvement of systems fixation such as roof to walls and walls to floors must be bear in mind to resist extreme weather events	4.38	1
3	Brick clad buildings can perform better with respect to extreme weather events	3.00	4
4	Building a levee or walls around the buildings and facilities may be a good solution to resist extreme weather events	2.53	5
5	Design for heavy wind load may play a role in adapting to extreme weather events	3.01	3

To face the rainfall changes, the results revealed that using of collection systems with greater capacity to solve the effects of rainfall changes that cause shortened rainy days. Ensuring well maintained for roofs and drainage systems to avoid side effects of rainfall changes, and using of insulation materials to resist the effects of rainfall on building are the most important factors with ($\bar{X}$ = 4.21), ($\bar{X}$ = 4.12) and ($\bar{X}$ = 4.09) respectively. The concern was oriented to two groups; the first was about development of the total networks and collection system in attempt to solve the major problem from general view, the second group was about trial steps to solve the problem within the buildings, which reflect the view for small group. This high rate of responses reflects the need of efforts to apply the required mechanism for the both levels whether the large represented by the collection system or small represented by specified buildings.

For the rank of procedures for extreme weather events, the top two results were about improvement of systems fixation such as roof to walls and walls to floors. Ensuring well maintained for roofs and drainage systems to avoid side effects of rainfall changes and using of external claddings and glazing to reduce the effects of extreme weather events on buildings with ($\bar{X}$ = 4.38) and ($\bar{X}$ = 4.06) respectively. This indicates the importance of recurring maintenance to avoid any risks that may occur in future. Furthermore, the results pointed out one of the new systems in the Gaza Strip represented by cladding and glazing which emphasizes on the extent of their usefulness in order to mitigate the risks of extreme weather events.

V. CONCLUSION

This study was based on quantitative approach. The aim of this research was to provide a platform of knowledge for the construction management practitioners about the impacts of climate change on the construction projects lifecycle. The primary objectives of this research were to review the climate change trajectory at Palestine – Gaza Strip area, to identify the most affected phases by climate change factors through the construction projects lifecycle and to propose rational approach to assist the construction professionals to benchmark their efforts with different phases together, which would minimize the influence of climate change. 127 factors were studied through the different phases of the construction projects lifecycle. The

factors were about the influence of climate change on the construction projects lifecycle whether by temperature, rainfall, or extreme weather events, and about the required procedures to face climate change within construction industry.

After exploring the influence of climate change on the construction project lifecycle, it can be concluded that:

All evidence proves that the climate change across Palestine in general and Gaza Strip as special case is witnessed and there is strong scientific consensus that the climate is changing. The most significant influence on the construction project lifecycle was related to the extreme weather events, rainfall change, and temperature change respectively. The most significant effects due to the temperature factor on the construction projects lifecycle were related to execution phase, planning, and design phase, initiation phase and closing phase respectively. The most significant effects due to the rainfall factor on the construction projects lifecycle were related to execution phase, planning, and design phase, closing phase and initiation phase respectively. The most significant effects due to the extreme weather events factor on the construction projects lifecycle were related to execution phase, closing phase, planning, and design phase and initiation phase respectively.

The most important factors that the temperature change expects to affect are concrete curing, concrete casting and workability, concrete hardening, choice of site location and increase in the minimum required standards of building code. The most important factors that the rainfall change expects to affect are concrete curing, structural damage which lead to excessive cost, high volumes of claims for insurance companies, delay in handing over to the clients, excavation and earthwork. The most important factors that the extreme weather events expects to affect are concrete curing, high volumes of claims for insurance companies, delay in handing over to the clients, structural damages which lead to excessive cost and the use of tower, cranes and scaffoldings.

The most effected lifecycle phases by various climate change factors were the influence of extreme weather events on the execution phase, the influence of extreme weather events on the closing phase, the influence of extreme weather events on the planning and design phase, the influence of rainfall on the execution phase and the influence of rainfall on the planning and design phase.

The research asserted on the importance of working to develop serious mechanism to implement strategies in order to mitigate or adapt with the effects of climate change, whether on the managerial level or towards the various factors of climate change.

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