An Exploratory Study on the Impact of the Construction Industry on Climate Change

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An exploratory study on the Impact of the Construction Industry on Climate Change

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KEYWORDS

Climate Change
Construction Industry
Sustainable Construction
Climate Change Adaptation
Climate Change Impacts

ABSTRACT

In the last decade, the construction industry in Egypt has been booming, and many mega projects are under construction. The lack of awareness of the construction industry's impact on climate change could be very harmful in terms of CO_2 emission, water and soil pollution, etc. This paper aims to explore the critical factors in the Egyptian construction industry that continue into climate change. Moreover, given the shared features between the construction industry in Egypt and those in other countries, this research could also shed lights on the general impacts of the construction industry on the various aspects of climate change. So, to achieve this aim, an intensive literature review was carried out to identify various factors contributing into climate change within the construction industry. This is followed by conducting 11 interviews with construction experts to explore any further factors throughout the lifecycle of a construction project. The identified factors from the literature review and the interviews were used to design a questionnaire survey to collect construction professionals' opinions on the impact of these factors on climate change in Egypt. 48 valid responses were received. The collected data were statistically analyzed to rank and determine the criticality level of these factors. The results revealed that the most significant factors influencing climate change are: the impact of industrial construction on climate change, the use of primary renewable energy as raw materials during the construction and use phases, and the effect of heavy civil and highway construction on climate change. The results also show that managing these factors requires considerable awareness and proactive actions during the project life cycle and pre-construction stage. The findings could inform decision-makers and construction professionals to raise awareness and make informed decisions to handle these key factors and minimize their potential contribution to climate change. Therefore, it can be recommended that construction clients may involve a climate change management plan as a requirement of tender documents.

1 Introduction and background

In a construction project, the lack of knowledge and awareness of the changing climate affects the surrounding environment and sustainability. The construction industry exerts significant impacts on the different aspects of climate change, such as: temperature changes, extreme weather events, increased sea level, increased CO_2, water pollution, lack of rain, desertification, and shrinking freshwater area. Therefore, the construction industry causes many climate change hazards, which will have dire consequences. On 5 Dec 1994, "Egypt joined the UN Framework Convention on Climate Change (UNFCCC),

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which establishes the fundamental guidelines and legal framework for international climate change cooperation to stabilize atmospheric GHG concentrations and prevent disastrous anthropogenic climate change." [1]; [2]; [3]; [4]. The United Nations Climate Change Conferences are annually held under the framework of the UNFCCC. The 27th United Nations Climate Change Conference (COP27) will be held in November 2022 in Sharm el-Sheikh, Egypt [5].

The NASA report [6], shows the temperature change in the last 50 years, as shown in Figure 1. Several studies have examined the impact of construction activities on climate change at the continental scale [[7]; [8]; [9]], while others have focused on the role of sustainable design in mitigating the climate change problem [10]; [11]; [12]. "The construction industry has limited potential to act on climate change given its position in the building supply chain" [13] [14]. Moreover, several studies analyze and have a key recommendation arising for reducing the construction CO_2 and GHG emissions to mitigate global warming to ensure the elimination of GHG emissions during the construction industry [[15]; [16]; [17]; [18]]. [19] assessed the sensitivity and structural patterns of CO_2 emissions from construction in China, India, Japan, Russia, and the USA in 2015. According to the statistical study for Global CO_2 emissions changes [20], the 1st largest CO_2 emitter was the power industry, the 2nd largest CO_2 emitter was another industry combustion, and the 3rd largest CO_2 emitter was transportation, as shown in Figure 1. Furthermore, a study by [21], as shown in Figure 2, shows the global annual CO_2 and GHG emissions status from 1990 to 2019.

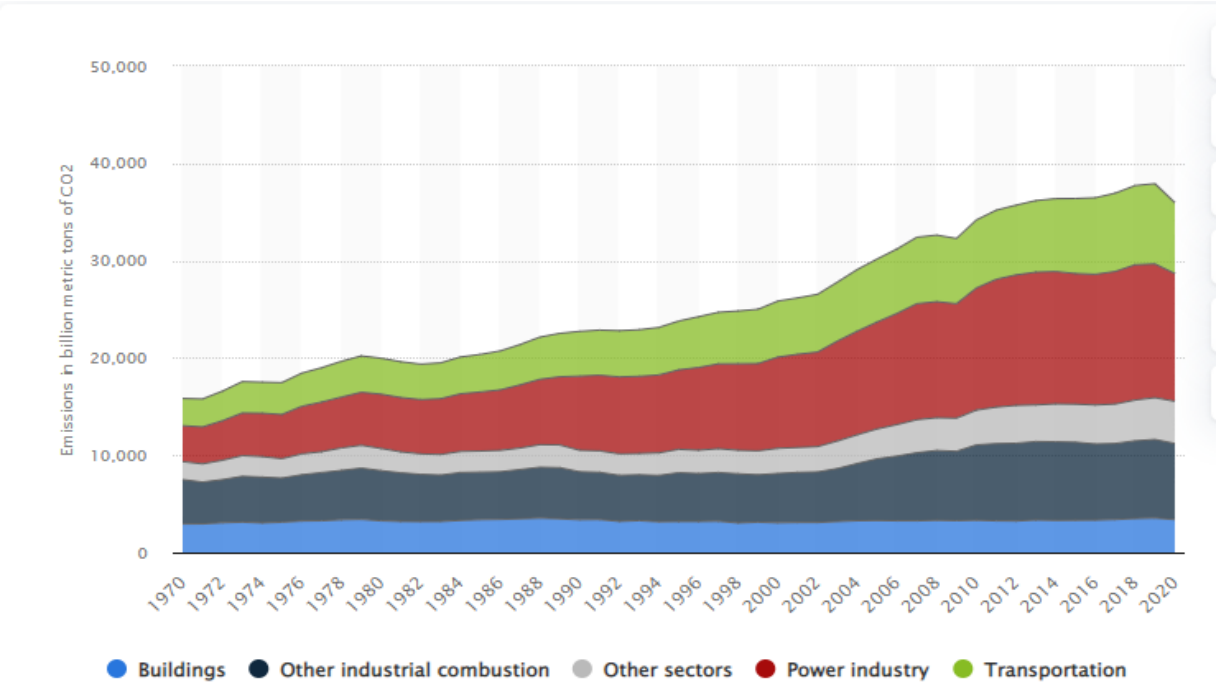

FIGURE 1: GLOBAL EMISSIONS IN BILLION METRIC TONS OF CO_2 [20] [22]

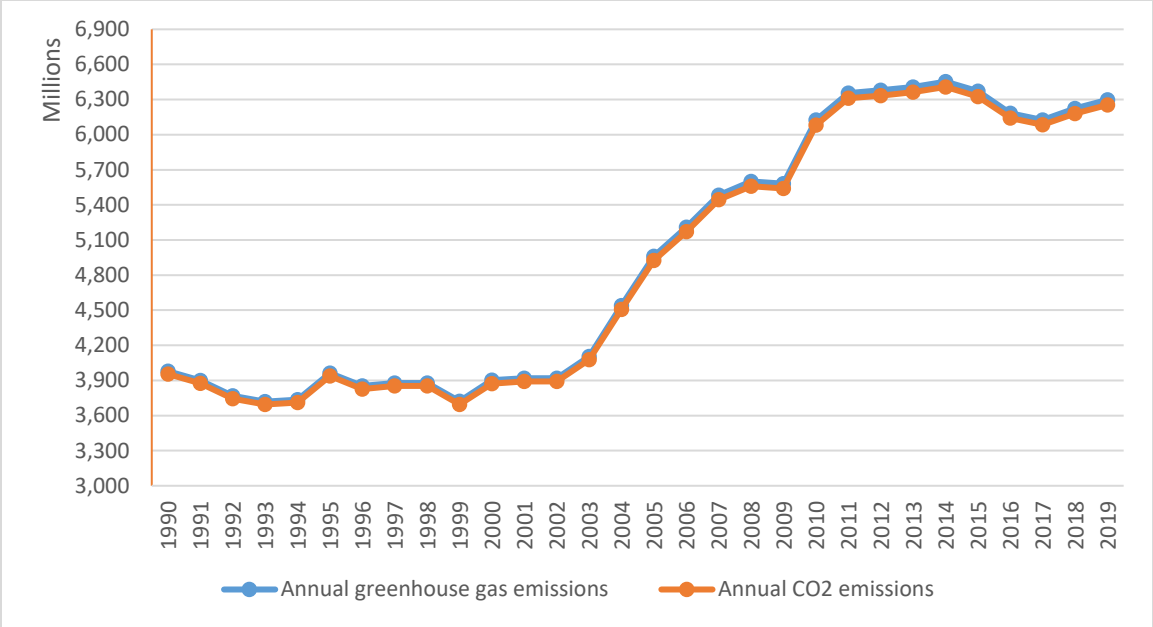

FIGURE 2: CO2 AND GHG EMISSIONS [21]

Climate change negatively affects the development of the construction industry [[23]; [14]; [24]] in several ways, including increased risk of construction delays, higher possibility of damage to buildings, construction equipment, and other assets, and increased costs for weather-related insurance and reinsurance. A variety of adaption techniques were described, some of which include:

- Build components off-site [23].
- Create management strategies for bushfires, cyclones, and hailstorms.
- Build structures on land elevated above sea level.
- Water and energy efficiency in design, construction, and retrofit.

Recent studies have conceptualized that the impacts of the construction industry on climate change will vary related to different locations. Still, they could include issues related to weather, water, and temperature [[25]; [23]; [14]; [24]; [26]]:

- Change in temperature
- Extreme weather events
- Increased sea level
- Increased CO_2
- Water pollution
- Lack of rain
- Desertification

Also, climate change negatively affects the development of other industries such as industrial engineering and regarding industrial integration that related to the construction industry [[27] [28] [29] [30] [31] [32] [33] [34] [35]].

As shown in Figure 3, the construction lifecycle (Selection of appropriate site, Design & Planning process, Fabrication, Delivery, Field Operation (Execution & Monitoring and Control and Closure stages), and Commissioning) has Environmental, Economic challenges, and Technological challenges. In addition, many

wrong methods in the construction industry cause damage to the climate, such as Low green areas in projects, decreasing forests, using unrenewable materials, using unrenewable energy, cement factories, destroying Cora reefs, and pollution of the marine environment.

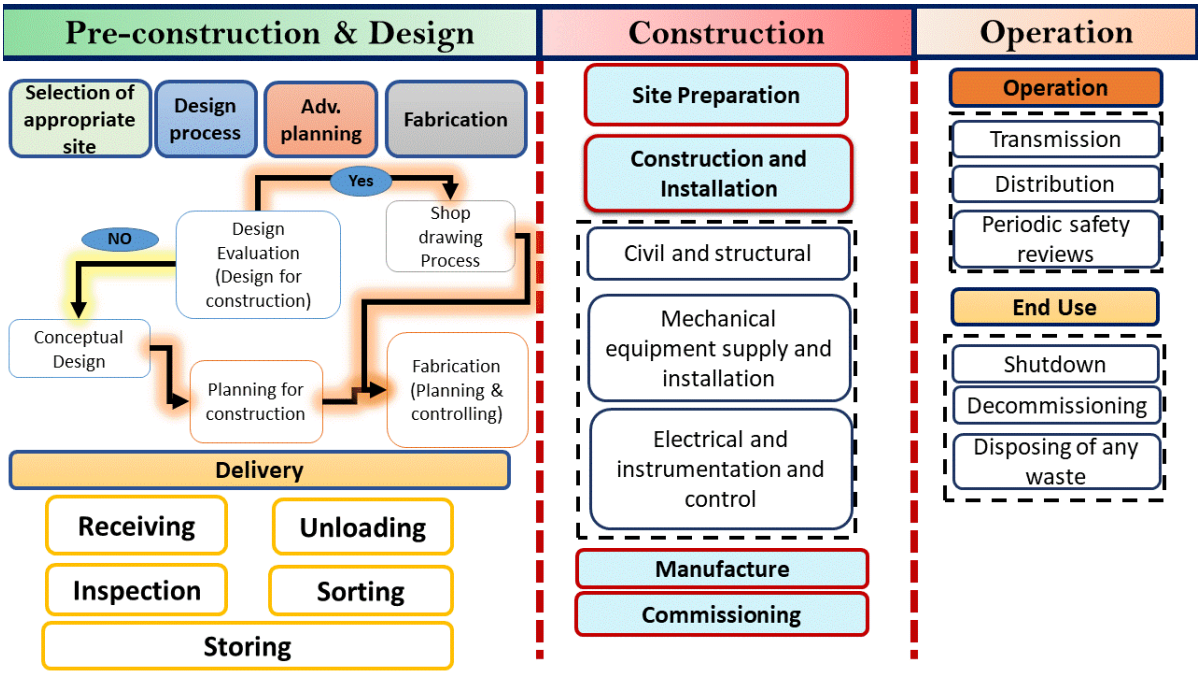

FIGURE 3: LIFE CYCLE COSTING FOR THE CONSTRUCTION INDUSTRY PROJECTS

Industrial Information Integration Engineering (IIIE) was proposed by Xu in 2011. In particular, IIIE consists of techniques for resolving complex issues in creating information technology infrastructure for industrial sectors, particularly with regard to information integration. IIIE is a set of fundamental concepts and techniques that facilitate the industrial information integration process. Through identifying the theoretical underpinnings, body of knowledge, frameworks, theories, and models at various levels, IIIE has been suggested and explored. (1) What scientific basis will give IIIE disciplinary support at the levels of frameworks, hypotheses, and models? is one of the important research topics addressed. and (2) How will real-world problem-solving help be offered at each level of the IIIE, i.e., frameworks, theories, and models/techniques? A complex gigantic system would have many of the same qualities as IIIE, an interdisciplinary subject [36]. Nearly every one of them is interacted with by IIIE at different tiers. IIIE interacts with computer science and engineering, industrial systems engineering, information systems engineering, and interdisciplinary engineering in terms of scientific and engineering methodologies at the methodological layer. At the application layer, IIIE collaborates with the fields of aerospace engineering, bioengineering, civil engineering, energy engineering, communication engineering, material engineering, and earth resources engineering to create and execute enterprise systems in many industrial sectors. IIIE collaborates with management and social science fields in addition to scientific and technical ones. [37]. Although several studies have been carried out to explore the construction industry's contribution to climate change, there is no study to explore the construction industry's contribution to climate change in Egypt. This is a timely, critical study, especially when there is a warning that Alexandria city and some other coastal cities in Egypt could be the first cities affected by climate change [38].

Unfortunately, the lack of awareness of climate change affects the surrounding environment and sustainability during the construction stage, according to the "2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) in 2015" [39], which aim to secure lasting social, economic, and environmental benefits at the national and local levels, while leaving no one behind. Also, the construction industry significantly impacts the different categories of climate change, such as; temperature changes, extreme weather events, increased sea level, CO_2, water pollution, lack of rain, desertification, and shrinking freshwater area. Therefore, this paper aims to explore the critical factors in the Egyptian construction industry that continue into climate change. Furthermore, this research is probably applicable in several circumstances, given the parallels between the Egyptian construction sector and many other affluent nations.

2 Research Methodology

This study reviewed the existing and recent literature to identify factors that impact climate change due to construction industry activities. Chart 1 briefly shows the methodology adopted in this study with three phases.

Phase 1: A critical analysis and evaluation of the relevant literature and 11 interviews with academics and construction professionals in the field were conducted to identify the factors influencing the construction industry's climate change. Phase 1 is carried out in two steps:

- Step 1: literature review, and
- Step 2: Interview survey.

Phase 2: A questionnaire survey was designed using the outputs of Phase 1 as input to the questionnaire. The questionnaire was then distributed to construction professionals in Egypt to obtain their thought on the identified factors.

Phase 3: The collected data was sorted and statistically analyzed to rank the factors and prioritize the required actions to handle the key factors and practices affecting climate change.

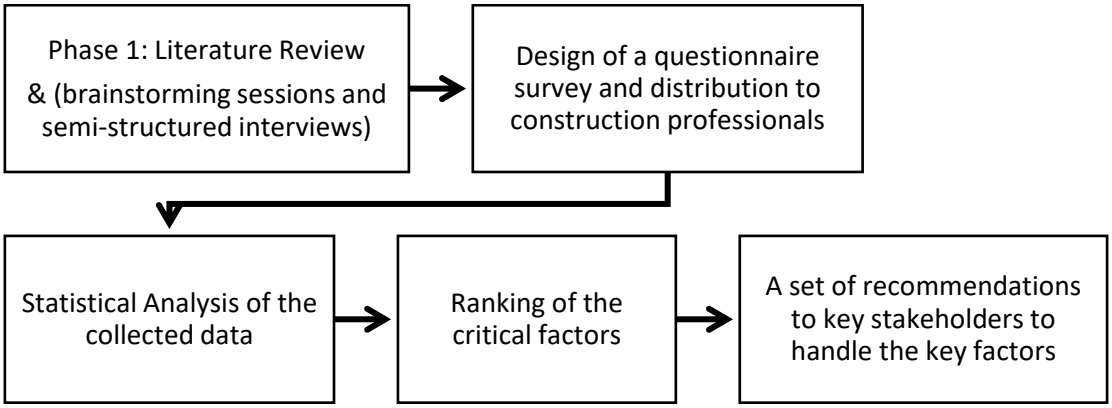

CHART 1: RESEARCH METHODOLOGY FLOWCHART

3.1. Phase 1: Literature Review and Interview

In the construction industry, similarities and differences could exist due to the construction practices, lack of regulations, such as; skills, awareness, the economic activities, or maybe some countries are industrial countries, or some countries currently are observing a boom in the economy (emerging markets) which needs more construction work. So, given the parallels between the Egyptian construction sector and many other affluent nations such as Hong Kong, Swedish, Australia, India, China, Japan, and Canada, as shown in Table 1.

TABLE 1: THE CONTRIBUTION OF THE PREVIOUS STUDIES RELATED TO DIFFERENT COUNTRIES

Study	Case Study / Applications	Contribution
[40]	Hong Kong Australia	• They compared Hong Kong and Australia for the structure of energy generation and the adoption and development of renewable energy. It was shown that the differences between the two locations in terms of their populations, cultures, politics, rules, economic conditions, and building practices were anticipated to significantly impact their ability to achieve net zero carbon race performance.
[41]	Hong Kong	• All long-term policies, infrastructure projects, company planning, and strategic investments must consider climate change risk. Decision-makers worldwide are starting to understand that to combat climate change; they must be proactive rather than reactive. Local companies and communities can only prepare for climate change and its associated dangers via planning.
[42]	India	• According to circular Economy methods evaluated using input-output analysis and the Leontief inverse matrix, the building and transportation sectors were the largest contributors to Carbon Footprint and Material Footprint.
[43]	Japan	• For a river basin in northern Japan, the individual and combined effects of changing land use and climate on water and sediment dynamics were examined. Climate change was shown to influence outflow substantially, and depopulation may modify sediment regimes (i.e., a shift in the source of sediment supply from watershed to channels). • It enhanced knowledge of how climate and land use change impact water and sediment movement in a river basin with a declining population.
[44]	China	• A Network-SVAR model was proposed to show the internal link between the carbon price and major building factors based on the Additive Bayesian Network technique. The construction industry must actively create carbon emission trading markets and use carbon derivatives to manage pricing risks and achieve the carbon neutrality target effectively.
[45]	Sweden	• Based on the experts' perspectives recorded, it is clear that the Swedish construction sector still has a long way to go before it completely meets the sustainability objectives. The requirement for a climate statement encompasses a significant portion of new development and impacts a wide range of industry participants. However, the requirements for this regulation should now be viewed as an informational tool. Given their scope limitations, it is probable that they will only have a minimal short-term impact on GHG emissions. However, the climate declaration should eventually result in information regarding the climate effect and, consequently, a shift in market players' conduct.
[14]	Australia	• The challenges facing the Australian construction sector in adapting to climate change. ○ Uneven and ambiguous language use, little regulation ○ Apparent inability to afford initiatives

		○ Insufficient knowledge of climate change, and ○ No client demand for projects to be carried out
[46]	Canada	• Numerous climate risks and impacts have been recognized, posing dangers to various forms of Canadian infrastructure. Industry professionals advise three alternatives for enhancing infrastructure's climate resilience: planning and evaluation, monitoring and maintenance, and structural adjustments.

The interviews with construction industry actors were conducted. Eleven interviews with construction experts (7 professionals and 4 academics) were conducted to explore any further factors that impact climate change throughout the lifecycle of a construction project. It was conducted face-to-face and by telephone, ranging from 30 min to 45 min. The interviews were semi-structured so that interviewer might ask random questions to examine further factors brought up as necessary and to clarify answers, as shown in Chart 2. In addition, a summary of the critical factors identified from the interview was added to table 2, which is not mentioned in the literature.

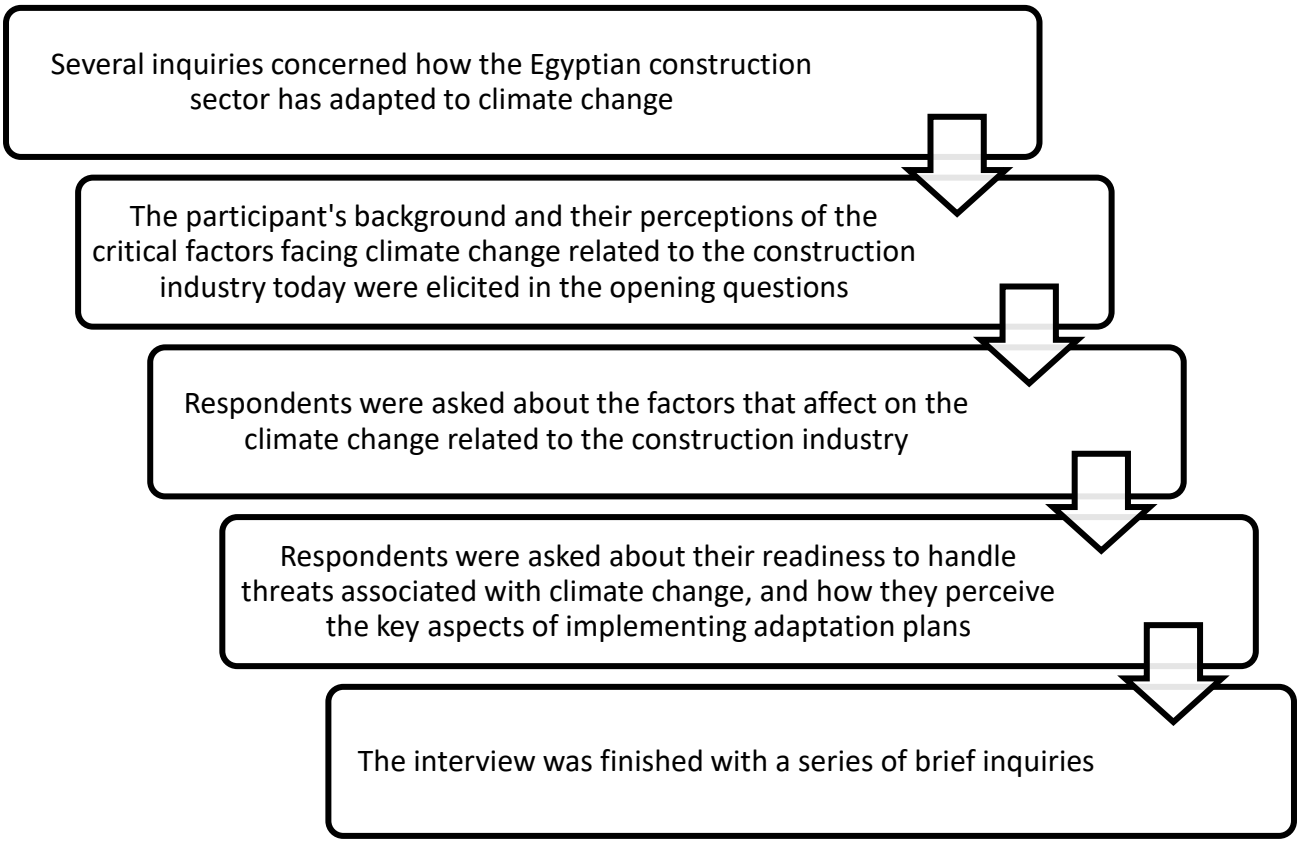

CHART 2: STEPS OF THE INTERVIEWS PHASE

International journals and various databases were also searched for research-relevant publications. As seen in Table 2, this review is based on studies on the influence of the construction sector on climate change that were retrieved from reputable academic journals up until the end of June 2022. Therefore, various studies also capture the causes of climate change due to the construction industry [[47]; [48]; [49]; [50]; [51]; [52] [18]; [53]; [54]]. Moreover, structured questionnaire interviews with construction experts were conducted in the geographical scope of Egypt to collect data, identify, and rank the critical

factors that impact climate change in the construction industry. The literature review highlighted the road pavements, combating climate change, safety climate in the construction industry, climate change in transportation infrastructure, and sustainable construction but pointed to the need to study the impact of the construction industry on climate change. In addition, the interviews indicated an interest in the factors that impact climate change according to the construction industry. Therefore, a structured questionnaire was conducted to study the economic, environmental, and technological challenges that can significantly reduce the change in climate during the construction industry. As a result, the following Twenty-nine (29) critical factors (7 factors from interviews with experts, 16 from literature review, and 6 from both), as shown in Table 2, were determined and ranked related to the pre-construction and construction stages.

TABLE 2: SHOWN THE POTENTIAL IMPACT OF THE CONSTRUCTION INDUSTRY ON THE CLIMATE CHANGE

S.N.#	Factors	Source/Reference	Effects
F1	Residential building construction activities	Interviews with Experts [14]	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F2	Commercial and Institutional building construction activities	Interviews with Experts	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F3	Heavy civil and highway construction activities.	Interviews with Experts [55]	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F4	Industrial construction activities.	Interviews with Experts	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2

			• Water pollution • Lack of rain • Desertification
F5	The extent to apply proper procedures and actions in the construction industry to minimize climate change impacts.	Interviews with Experts [24]	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F6	The extent to apply proper procedures and actions in the construction industry to reduce GHG emissions.	[17] [56]	• Change in temperature • Extreme weather events • Increased CO_2 • Water pollution
F7	The construction industry addresses infrastructure and sector decarburization goals (transition risks).	Interviews with Experts [55]	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F8	The construction industry cares about reducing carbon emissions and transition risks.	[17] [18] [56]	• Change in temperature • Extreme weather events • Increased CO_2
F9	Stakeholders take actions to combat climate change in the construction industry.	Interviews with Experts	• Change in temperature • Extreme weather events • Increased sea level • Increased CO_2 • Water pollution • Lack of rain • Desertification
F10	Reducing the potential negative effects of the construction sector on the environment due to land-use change or soil sealing (which can affect water flows after heavy rain) (carbon sequestration).	[56]	• Increased sea level • Lack of rain • Desertification
F11	Promoting the use of sustainable construction materials.	[18] [26]	• Extreme weather events • Change in temperature • Lack of rain • Increased CO2 • Desertification

F12	Abiotic depletion potential for fossil resources (ADP-fossil fuels) in the construction industry.	Interviews with Experts	• Lack of rain • Extreme weather events • Increased CO2
F13	Disposed of hazardous and non-hazardous waste during the construction stage.	Interviews with Experts	• Extreme weather events • Change in temperature • Lack of rain • Increased CO2 • Desertification
F14	The construction stage is through GHG (GHG) emissions.	[17] [18] [57] [58]	• Lack of rain • Increased CO2 • Extreme weather events
F15	increasing the resistance of materials to adverse weather throughout the building's construction and use.	[26]	• Increased sea level • Water pollution
F16	Overhauling heating/cooling and insulation concepts during construction and use phases.	[18]	• Extreme weather events • Change in temperature • Increased sea level • Lack of rain • Increased CO2 • Desertification • Water pollution
F17	Water management practices during the construction and use phases to be more climate-smart.	Interviews with Experts	• Increased sea level • Water pollution
F18	Selection of the appropriate site, site preparation, and design of the site layout and logistics during the construction phase.	Interviews with Experts	• Extreme weather events • Change in temperature • Increased sea level • Lack of rain • Increased CO2 • Desertification • Water pollution
F19	Choosing the construction materials.	[26] [51]	• Extreme weather events • Change in temperature • Lack of rain • Increased CO2 • Desertification
F20	Delivery of the materials to the site during the construction phase.	[26]	• Extreme weather events • Change in temperature
F21	Fabrication processes during the construction and use phases.	Interviews with Experts [59]	• Extreme weather events • Change in temperature • Increased CO2
F22	Soil sealing, erosion, and sediment process in the construction stage.	[14] [24]	• Increased sea level
F23	Method of construction during the construction phase.	[56] [59]	• Extreme weather events • Increased CO2

			• Desertification • Water pollution
F24	Heating, ventilating, air conditioning, and refrigeration (HVAC & R) equipment during construction and use phases.	[18] [57]	• Extreme weather events • Change in temperature • Increased CO2
F25	The waste of materials, equipment, and tools during construction.	[17] [26]	• Extreme weather events • Change in temperature • Lack of rain • Increased CO2
F26	Use of primary renewable energy as raw materials during the construction and use phases.	[18] [26] [57]	• Change in temperature • Increased sea level • Increased CO2 • Water pollution
F27	Utilize primary energy sources that are non-renewable as raw materials during the construction and consumption phases.	[18] [57]	• Change in temperature • Increased sea level • Increased CO2 • Water pollution
F28	Use of renewable secondary fuels during building construction and use phases.	[18] [57]	• Extreme weather events • Change in temperature • Increased sea level • Increased CO2
F29	Use of net freshwater during building construction and use phases.	Interviews with Experts	• Water pollution

3.2. Phase 2: Design a questionnaire and survey

Three sections and forty-three questions make up the survey questionnaire. As discussed in [59] [51], The study's introduction, which covers the research's background, expected outcomes, and essential question, is included in the first part. In the second section, there are inquiries concerning the respondents' backgrounds and the project details. The third section contains in-depth information about the factors and problems and their impact on climate change due to the construction industry activities throughout the construction lifecycle, as shown in the following parts (A, B, and C). It is decided to use a 5-point Likert scale (very low, low, moderate, high, and very high) to assess how much impact certain elements have on climate change. In this study, the corresponding survey was conducted after the questionnaire was developed. In addition, this study uses a web-based questionnaire to collect the respondents' opinions.

A. 1st Part of the questionnaire: general question for respondents.
B. 2nd Part of the questionnaire: the Awareness level of institutions about the impact of climate change, as discussed in [24] and [51].
C. 3rd Part of the questionnaire: The impact of this factor on climate change in the construction industry and the degree of effect.

3.3. Phase 3: Data analysis

3.3.1 Background of respondents

As a result, 48 construction professionals from Egypt completed the questionnaire survey. These respondents' backgrounds and awareness levels on the climate change impacts in their organizations are

displayed in Figures 4, 5, and Table 3, respectively. The statistical analysis was carried out by using IBM® SPSS® Statistics 25. According to the project organizations where the respondents are affiliated with, 48.9% are academic, 8.9% are consultants, 15.6% are contractors, 2.2% are subcontractors, 11.1% are designers, and 13.3% are owners, as shown in Figure 4. Therefore, Since practically every field associated with the construction industry is represented in the respondents' occupations, the data is more representative. As reported by the respondents, the average percentage level of the construction industry's impact on climate change 20% of respondents said that he average percentage level of the construction industry's impact on climate change is (0 - 20%), 42.2% of respondents said that the average percentage level of the construction industry's impact on climate change is (20% - 40%), 26.7% of respondents said that he average percentage level of the construction industry's impact on climate change is (40% - 60%), 6.7% of respondents said that he average percentage level of the construction industry's impact on climate change is (60% - 80%), and 4.4% of respondents said that he average percentage level of the construction industry's impact on climate change is (More than 80%), as shown in Figure 5. Table 3 shows the details of the Awareness level of institutions about the impact of construction on climate change. 35.6% of stakeholders complained about the impacts of construction on climate change (noise-solid waste-dust). 40% of respondents consider the construction industry's adverse impacts on climate change. 42.2% attempt to find a proposal or a practice solution to mitigate the effects of construction on climate change. Also, 44.4% have an environmental impact assessment system, and 48.9% seek to address harmful climate impacts. In the construction phase, 40% consider renewable energy (solar or wind power), 35.6% consider reducing carbon emissions to a level that prevents global warming from increasing by more than 1.5 °C (3 °F), and 51.1% think about the solution to climate change as well as measures to prepare for its effects. This indicates that the building sector has to improve in several areas related to climate action. From the results, the Egyptian construction industry prepared for climate change to reduce /or eliminate any emissions (GHG emissions).

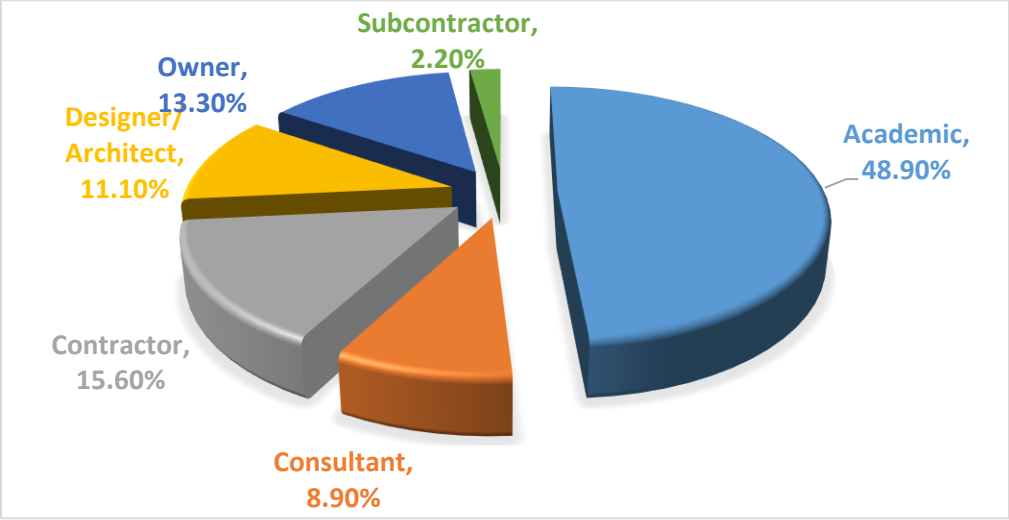

FIGURE 4: DETAILS FOR THE ORGANIZATION TYPE

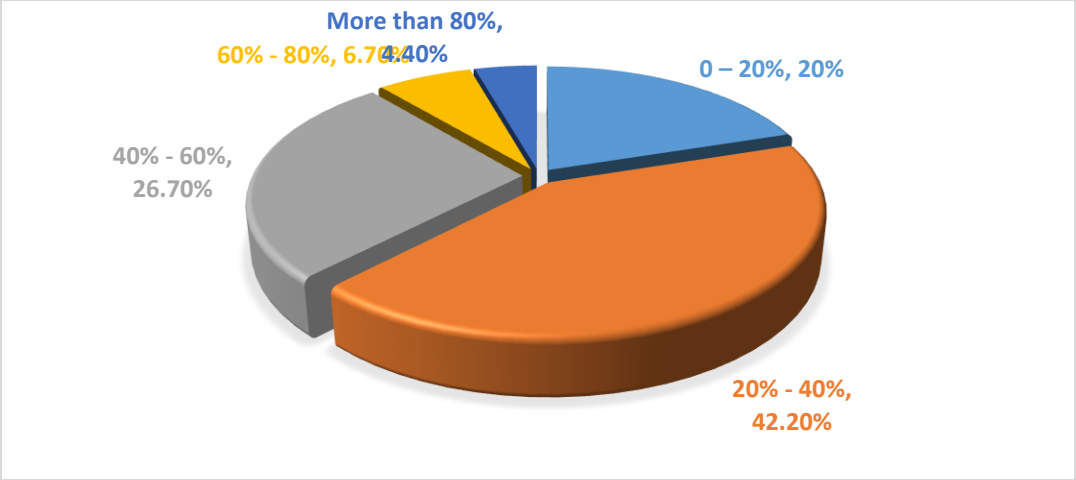

FIGURE 5: SHOWS THE AVERAGE PERCENTAGE LEVEL OF THE CONSTRUCTION INDUSTRY'S IMPACT ON CLIMATE CHANGE

TABLE 3: DETAILS OF THE AWARENESS LEVEL OF THE ORGANISATION ON THE IMPACT OF CONSTRUCTION ACTIVITIES ON THE CLIMATE CHANGE

Factors	Yes	No	Maybe
Does your institution consider the adverse impacts of construction on climate change?	40%	31.1%	28.9%
Does your institution attempt to find a proposal or a practice solution to Mitigate the Impacts of construction on climate change? [60]	42.2%	31.1%	26.7%
Does your institution have an environmental impact assessment system? [60]	44.4%	31.1%	24.4%
Does your institution consider renewable energy (wind power or solar power) in the construction stage?	40%	40%	20%
Does your institution think about lowering carbon emissions so that we can keep global warming to a maximum of 1.5 °C (3 °F)?	35.6%	31.1%	33.3%
Does your institution seek to address harmful climate impacts?	48.9%	28.9%	22.2%
Does your institution consider the need to combat climate change and include measures to adapt to the impacts of global warming? [61]	51.1%	26.7%	22.2%
Have any stakeholders ever complained about the impacts of construction on climate change (noise-solid waste-dust)?	35.6%	31.1%	33.3%

3.3.2 Ranking of construction related-factors influencing climate change,

To determine the crucial factors that influence climate change in the building sector throughout the construction lifecycle, the data collected from the third section of the questionnaire was analyzed in verbal words in the 5-point Likert scale was converted into numerical values, where (very high equaling 5, high equaling 4, moderate equaling 3, low equaling 2, and very low equaling 1). Then, the relative significance index technique is used to gauge the components' influence on climate change in the construction industry. The RII formula is:

$$RII = \frac{\sum s_i n_i}{AN} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{5N} \quad (1)$$

Where A is the highest point in this research, five, Si is the point awarded to significance level I, ni is the number of respondents indicating importance level I, and N is the total number of respondents. RII has a range of 0 to 1 [62]. The significance of the components increases with R-value. The rank of the factors may then be determined. These rankings allow for comparing the components' respective weights, as illustrated in Table 4.

TABLE 4: RII SCALE (SOURCE: BHIRUD & VASANT, 2015)

RII Scale	Impact
0.00-0.20	Not critical (NC)
0.21-0.40	Fairly critical (FC)
0.41-0.60	Average critical (AC)
0.61-0.80	Very critical (VC)
0.81-1.00	Extremely critical (EC)

When examining the distribution of survey data, the coefficient of variation is used to gauge the degree of dispersion. The equation is:

$$\text{Coefficient of Variation } CV = \frac{\sigma}{\overline{X}} \quad (2)$$

$$\text{Mean } \overline{X} = \frac{\sum_{i=1}^{N} x_i}{N} \quad (3)$$

$$\text{Standard Deviation } \sigma = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \overline{X})^2}{N}} \quad (4)$$

3 Results and Discussions

The results of the analysis are presented in Table 5. Based on the value of RII, factors are ranked in order of importance. The rank increases in direct proportion to the RII and vice versa. The importance rating of two or more factors would be the same if their values were equal. Depending on the outcomes and the RII value, as indicated in Table 5, all factors are more significant than 0.61 (0.62-0.78); F9 is the less important, and F4 is the highest importance. Therefore, every factor gathered from the research and interviews is a significant factor influencing climate change in Egypt across the entire construction industry.

TABLE 5: RESULTS OF STATISTIC ANALYSIS

Factors	Sum	Mean	Std. Deviation	Variance	CV	RII	Critical	Rank
F1	153	3.40	1.136	1.291	0.33	0.68	VC	19
F2	155	3.44	1.056	1.116	0.31	0.69	VC	16
F3	170	3.78	0.927	0.859	0.25	0.76	VC	3
F4	175	3.89	0.910	0.828	0.23	0.78	VC	1
F5	152	3.38	0.984	0.968	0.29	0.68	VC	21
F6	155	3.44	1.035	1.071	0.30	0.69	VC	19
F7	153	3.40	1.031	1.064	0.30	0.68	VC	20
F8	142	3.16	1.242	1.543	0.39	0.63	VC	23

F9	139	3.09	1.345	1.810	0.44	0.62	VC	24
F10	151	3.36	1.090	1.189	0.32	0.67	VC	22
F11	160	3.56	1.056	1.116	0.30	0.71	VC	12
F12	145	3.22	0.951	0.904	0.30	0.64	VC	22
F13	160	3.56	1.035	1.071	0.29	0.71	VC	13
F14	161	3.58	0.917	0.840	0.26	0.72	VC	11
F15	169	3.76	0.802	0.643	0.21	0.75	VC	5
F16	155	3.44	0.967	0.934	0.28	0.69	VC	18
F17	156	3.47	0.968	0.936	0.28	0.69	VC	15
18	162	3.60	1.074	1.155	0.30	0.72	VC	10
F19	168	3.73	1.136	1.291	0.30	0.75	VC	6
F20	153	3.40	1.095	1.200	0.32	0.68	VC	22
F21	160	3.56	1.035	1.071	0.29	0.71	VC	14
F22	158	3.51	1.079	1.165	0.31	0.70	VC	14
F23	162	3.60	0.915	0.836	0.25	0.72	VC	11
F24	166	3.69	0.973	0.946	0.26	0.74	VC	7
F25	170	3.78	0.902	0.813	0.24	0.76	VC	4
F26	171	3.80	1.036	1.073	0.27	0.76	VC	2
F27	164	3.64	1.026	1.053	0.28	0.73	VC	8
F28	156	3.47	1.014	1.027	0.29	0.69	VC	17
F29	163	3.62	1.211	1.468	0.33	0.72	VC	9

The CV of most components is between 0.2 and 0.5, as indicated in Table 3. Data dispersion is, therefore, of a medium degree. It is very important to some respondents yet relatively unimportant to others.

Results from this study can help the decision-makers mitigate the effects of climate change to minimize or eliminate the factors in the construction industry that contribute to climate change. This paper concluded with a recommendation for reducing the potential impact of the construction industry on climate change and revealed the need and gap in efficient assessment criteria in the construction industry. So, it is classified as related to the responsibilities (Client & Government & Academics & Contractor); also, we classified the factors related to regulations, management, finance, cultural, and technical issues, as shown in Table 6. This study helps the decision-makers fully consider the future construction industry's positive and negative impacts when developing climate change strategies.

TABLE 6: CLASSIFY THE FACTORS RELATED TO THE RESPONSIBILITIES AND SITUATION

S.N.#	Stakeholders / Responsibilities	Situation
F1	Client & Government	Regulations & Management
F2	Client & Government	Regulations & Management
F3	Client & Government	Regulations & Management
F4	Client & Government	Regulations & Management
F5	Contractor	Technical & Cultural
F6	Contractor	Technical & Cultural
F7	Client & Government	Finance & Technical & Cultural
F8	Client & Contractor	Technical & Cultural
F9	Client & Contractor	Finance & Technical & Cultural

F10	Client & Contractor	Technical & Cultural
F11	Academics & Contractor	Finance & Technical & Cultural
F12	Contractor	Technical & Cultural
F13	Contractor	Finance & Technical & Cultural
F14	Contractor	Technical & Management
F15	Client & Contractor	Technical & Management
F16	Academics & Client & Contractor	Technical & Management
F17	Contractor	Technical & Management
F18	Client	Technical & Management
F19	Contractor	Technical & Management
F20	Contractor	Technical & Management
F21	Contractor	Technical & Management
F22	Contractor	Technical & Management
F23	Contractor	Technical & Management
F24	Contractor	Technical & Management
F25	Contractor	Technical & Management
F26	Academics & Client & Contractor	Technical & Management
F27	Academics & Client & Contractor	Technical & Management
F28	Academics & Client & Contractor	Technical & Management
F29	Contractor	Technical & Management

These findings are consistent with existing research on how to implement the right policies and practices in the construction industry to lessen the effects of climate change and reduce GHG emissions [[24]; [17]; and [56]] that affect climate change. Consistent with [[17]; [58]], who found that GHG emissions should be controlled in the construction stage. This has parallels to research in the [[18]; [26]; and [57]] that the use of primary renewable energy as raw materials during the construction and use phases is a high impact on climate change during the construction industry. These findings are aligned with existing literature which found that choosing the construction materials and delivery of the materials to the site during the construction phase [26] and [51] have the main impact on climate change. This is in line with work that promotes sustainable construction materials during the construction industry [16] and should be considered in the construction phase.

4 Suggestions and recommendations to combat climate change in the construction industry

In the construction sector, the decision-makers should be predicted the factors that impact climate change. Therefore, it will help us to reduce /or eliminate any emissions (GHG emissions). During the preconstruction & design stage, the institution should be considered renewable energy (wind power or solar power), promote the use of sustainable construction materials, selection of the appropriate site, site preparation, and design the site layout and logistics during the construction phase, choose the construction materials, modifying water management practices to implement more climate-smart water management systems during the building and usage stages, to keep global warming to no more than an additional 1.5 °C (3 °F) through reducing carbon emissions [61], materials must be made more resilient to extreme weather conditions both during the construction and usage phases of buildings, as well as heating/cooling and insulation systems. During the construction stage, we should predict the factors that impact the construction stage on climate change through GHG (GHG) emissions. Stakeholders take actions to combat climate change in the construction industry [49], such as; applying proper procedures and

actions in construction industry to reduce GHG emissions and minimize climate change impacts, the construction industry's potential environmental harm from soil sealing (changes in water flows from heavy rain) or land-use change (carbon sequestration) [49], as well as the possibility for abiotic resource depletion (ADP-fossil fuels), are all part of the solution to climate change. Additionally, measures to adapt to the effects of global warming, reduce noise-solid waste-dust, dispose of hazardous and non-hazardous waste during the construction stage, and deliver the materials to the construction site are Use of secondary materials during the construction and use phases [63], use of renewable primary energy resources used as raw materials during the construction and use phases, and use of primary renewable energy resources excluding primary renewable energy resources used as raw materials during the construction and use phases of buildings. The organization and stakeholders should consider how to combat climate change and incorporate strategies for adapting to its effects, apply proper procedures and actions in the construction industry to minimize climate change impacts, and apply appropriate procedures and actions in the construction industry to reduce GHG emissions.

5 Conclusions

Currently, the construction industry faces major challenges due to climate change. Recently, the impact of climate change has received increasing attention from researchers worldwide. The paper discusses many issues concerning the construction industry's impact on climate change. According to the respondents, the average percentage level of the construction industry's impact on climate change 20% is (0 - 20%), and 42.2% is (20% - 40%). Also, 40% consider the construction industry's adverse impacts on climate change. To lessen the effects of building on climate change, 42.2% of respondents attempt. Therefore, it is crucial to identify and rank the critical factors that impact climate change in the construction industry at the preliminary stage to provide the necessary information to construct a sustainable construction project. Also, it will incorporate climate change mitigation objectives at the construction stage. This research has identified the main factors impacting the construction industry's climate change.

The significance of including the construction industry's impact on climate change in the feasibility assessment is also highlighted in this research. This paper's conclusion suggested lowering climate change in the construction sector and emphasized the necessity for effective evaluation criteria consistent across the industry. In order to promote concrete efforts to address climate change risk in the building sector, we must prepare the global construction industry for the future. For instance, raising people's knowledge of the effects of climate change and putting current remedies to use.

The findings assist in increasing options for decision-makers to reduce GHG emissions in construction projects. For the Egyptian construction sector to be fully capable of addressing climate change in the future, the results revealed that managing the elements in the pre-construction and construction stages can significantly reduce the influence of climate change. The findings of this study can assist decision-makers in reducing or eliminating climate change-related issues in the construction sector in order to lessen the effects of climate change. In its conclusion, this article suggested lowering climate change in the construction sector and stressed the necessity of effective evaluation standards. This study helps the decision-makers fully consider the future construction industry's positive and negative impacts when developing climate change strategies.

Although this research presents a useful analysis to identify, explore, and rank the critical factors in the Egyptian construction industry that impact climate change, this study still has limitations. For the

construction industry's future, it must reach its total capacity to address climate change [24]. The three main factors identified are: firstly, the utilization of non-renewable primary energy sources, except those that are employed as raw materials during construction and usage; secondly, Increasing the durability of materials against extreme weather conditions during the construction and use phases of buildings [49]; and finally, choosing the construction materials.

A conflict of interest

The corresponding author states that there is no conflict of interest on behalf of all authors.

Data Availability Statement

The submitted article appears all data, models, and code generated or used during the study.

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