ISSN: 2538-2152; ECOPERSIA 2024;12(2):153-173.

Evaluating Climate Change Underwriting Approaches in Iran's Insurance Industry

ARTICLEINFO

Article Type
Original Research

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How to cite this article
Hamzeh A., Farzaneh M.R., Banimostafaarab F., Khordadi M.J. Evaluating Climate Change Underwriting Approaches in Iran's Insurance Industry. ECOPERSIA 2024;12(2): 153-173.

DOI:
10.22034/ECOPERSIA.12.2.5

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Article History
Received: February 17, 2024
Accepted:May 8, 2024
Published: May 20, 2024

ABSTRACT

Aims: Global warming and, as a result, climate change has caused significant changes such as increasing temperature, increasing atmospheric hazards, and decreasing rainfall in recent decades in different regions of the world, especially mid-latitudes like Iran. Providing appropriate strategies for climate change insurance plays a vital role in climate change adaptation and mitigation. It is essential to consider products and services when underwriting. The insurance strategy of direct insurers (reinsurers) should be under actuarial risk-based principles. Therefore, every decision and action taken by insurance institutions with climate change adaptation requires a risk assessment. The insurance strategy of an insurer can seek to promote insurance solutions for economic activities and, as a result, sustainability goals or characteristics for various reasons. Furthermore, insurers should refrain from making unaffordable insurance decisions. Therefore, examining international underwriting and dealing with the climate change insurance process in Iran can provide helpful strategies to managers. This research has been done to investigate the situation of Iran's insurance industry in the underwriting of climate change.

Materials & Methods: Initially, insurance plans, coverage, and climate change risk management strategies are reviewed in selected developed and developing countries. Then, the experiences of global surveys, including questioning based on the exposure of the American insurance industry, the climate change survey of the Bermuda Monetary Authority, the global survey of the financial plan of the United Nations Environment Program, and the insurance survey of the Scandinavian region regarding climate change are used to develop a questionnaire in line with the current situation of Iran country in the field of climate change insurance. The respondents to the questionnaire were selected purposefully and non-probably, and the selection was based on their deep understanding of the subject under study and their participation in the climate change risk management process. Finally, 35 experts filled out the questionnaire.

Findings: The results of the questionnaire's analysis distributed among insurance experts on climate change risk management show that some insurance companies, despite predicting the impact of climate risks in their insurance processes and empowering their employees, do not have any plan for the assessment and mitigation of greenhouse gases, regular assessment of climate hazards, providing incentives and modeling. Also, the strategy of annual repricing and risk-based pricing is the highest priority for insurance companies facing climate change.

Conclusion: Most of the country's insurance companies use different strategies to deal with climate change, of which annual repricing and risk-based pricing have been the most popular. Use of natural disaster insurance funds, parametric and non-parametric analytical techniques in risk calculation and evaluation, development of insurance products related to climate change, natural disaster prevention and control systems, simulation and modeling of natural disasters, use of digital maps of natural disasters, land use, creating safe infrastructure, climate risk insurance facilities, and protection and restoration of ecosystems are placed in the following categories, respectively.

Keywords: Risk Management; Pricing; Climate Risk Assessment; Insurance Companies.

CITATION LINKS

[1] IAIS., Issues Paper on Climate Chan... [2] IPCC., Climate Change 2014: Impacts... [3] IPCC., Climate Change 2022: Impacts... [4] Farzaneh M., Zamani B.,Hamzeh A. Ri... [5] EIOPA., On non-life Underwriting an... [6] Golnaraghi M. Climate change and th... [7] Kondrup C., Mercogliano P., Bosello... [8] CCS. Analyzing catastrophe data in ... [9] Walkowicz T. Italian Non-Life incor... [10] OECD. OECD Environmental Performanc... [11] Shiravand H., Hamzeh A., Alibakhshi... [12] PIAM. PIAM Member Companies Expedit... [13] Roslan R., Omar R. C., Hara M., Sol... [14] French C.C. America on fire: climat... [15] Kong F., Sun S. Better understandin... [16] Sandberg E., Økland A., Tyholt I.L.... [17] Thiebes B., Winkhardt-Enz R., Schwa... [18] USAID. Climate Risk Profile: Mexico... [19] NAIC. Climate Risk Disclosure Surve... [20] BMA. Climate Change Survey Report. ... [21] UNEP FI. Insuring Climate Resilienc... [22] CO2focus, Assessing risks and imple...

[DOI: 10.22034/ECOPERSIA.12.2.5]

Introduction

Global warming and climate change have affected humans and nature in recent years. The scientific connection between carbon emissions and global warming is undeniable. *The Intergovernmental Panel on Climate Change* (IPCC) has clearly stated the human impact on the climate. It has been declared that the atmospheric concentration due to the emission of greenhouse gases due to human activities has reached its highest level in human history. In the past three decades since 1850, the Earth's surface has been warmer each decade than the previous decade. The hottest temperature on the planet was recorded in 2001, and after that, the increasing trend of temperature continued for about 17 years compared to the previous decades. The year 2017 is the second warmest year recorded since 1880 and the warmest year without the effect of El Niño. Among the effects of climate change are the increase in natural disasters and extreme weather events, the increase in the sea level, the decrease in biodiversity, the migration and movement of people due to natural events, and the increase in infectious diseases. There is strong scientific evidence that climate change affects the frequency, intensity, and distribution of natural disasters and extreme weather events [1, 2, 3]. Climatic factors affecting insurers are classified as physical, transition, and liability risks. Each of the above climatic risks may have different consequences on insurers depending on the main field of insurance activities, strategies for allocating investment amounts, risk level, expertise, geographical scope, and people's residence. The most critical risks imposed on the business and performance of insurers by climate risks include investment, market, strategic, operational, credit, financial, liquidity, legal, and regulatory risks [4].

Climate change affects several aspects of the insurance process and pricing of non-life insurance companies, creating challenges for the insurability of climate risks. Therefore, it will be more difficult to determine the amount of possible loss, which can also affect the randomness and correlation of events. In addition, premiums may also increase due to climate change, reflecting increased risks. Consumers' willingness to pay for insurance may also be less than the premium accepted by insurers to transfer risk, which makes the insurance market for climate events unsustainable [5].

The scientific gap and the uncertainty of the climate change process in catastrophe models may cause the risk of catastrophic events that are not considered in the rate and reserve systems, which is called underwriting risk. Regarding the viability of their business models, general insurance providers may face a unique combination of physical and transition risks that affect the level of demand for insurance products and services. Such changes may pose extensive risks to providers. In general, climate change affects the main components of underwriting, which include information required for risk assessment, accident location, insured losses, availability of reinsurance, cost, competitive considerations, investment, and insurability. It is essential to consider products and services in underwriting. The insurance strategy of direct insurers (reinsurers) should be under actuarial risk-based principles. Therefore, every decision and action insurance institutions take with climate change adaptation requires risk assessment. The insurance strategy of an insurer can seek to promote insurance solutions for economic activities and sustainability goals or characteristics for various reasons. Also, this should not lead to insurers making unaffordable insurance decisions.

Iranian insurance companies have no

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separate risk management unit for climate change. Natural disaster insurance is also not provided separately, and the secondary coverage is in fire insurance. Therefore, examining international underwriting and Iran's climate change insurance process can provide managers with valuable strategies. Weather risks are insurable. However, insurers need to adapt their models to variable parameters to improve risk assessment and ensure the insurability of weather risks in the face of great uncertainty. Insurers should also follow scientific findings and use the latest knowledge to avoid human error in recording historical data and better understand the recording and estimation of losses using past data. They should implement adaption measures specific to each location to update and improve risk models [6]. For more information about climate risk modeling, refer to [7]. This book reviews the methods and tools for modeling adaptation to climate change, creating guidelines for their use, and presenting cases of use as operational examples for their rapid deployment.

Global warming and climate change are happening all over the world. Developed and developing countries are not immune from the consequences of climate change. The purpose of examining the experiences of these countries is to study the types of climate change insurance methods and their development and adaptation to the current situation in Iran to pay attention to the climate change insurance process.

International Experiences

The share of insured losses is higher in developed countries, and governments seek to provide solutions and respond to the effects of climate change; these countries usually have more adaptive capacity, including technology and economic means, to bear the costs. On the other hand, the adverse effects of events caused by climate change are significant in developing countries. These countries, despite the most damaging effects of climate change, due to problems such as the lack of natural disaster insurance mechanisms, lack of awareness among people about the benefits of insurance, lack of access to reliable and comprehensive data to estimate the effects of climate change, and so on, have less ability to deal with its consequences [4,6]. The following section reviews climate change underwriting methods, including insurance plans and coverage and risk management strategies in the selected developed and developing countries.

- Insurance coverage offered for weather and climate risks in Spain distinguishes between residential, commercial, industrial property, equipment, and infrastructure, personal injury covered by the unusual risks plan, and agricultural products covered by hybrid agricultural insurance. All risks are covered throughout Spain without geographic distinction and private and public participation principles. In Spain, indemnity insurance schemes and coverages include the Insurance Indemnity Consortium, the Hybrid Agricultural Insurance, and the IDEA project (Improvement of Damage Assessment to Improve Cost-Benefit Analysis). Adaptation to climate change in Spain compiles a set of responses to reduce the risks caused by climate change, which will intensify and expand in the coming decades and according to climate forecasts. The National Climate Change Adaptation Plan (PNACC), since 2006, has constituted the reference framework that guides public efforts to strengthen knowledge and adaptive responses to climate change in Spain [8].
- Italy's general property insurance market is dominated by four companies, Generali, Unipol, Allianz, and Rila Miocea, which cover 70% of the market, and natural disaster coverage includes voluntary home

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insurance renewal. Overall penetration rates are also meager due to low-risk perception and temporary loss coverage, and most insurance policies cover damage such as hurricanes and hail, while flood policies are less common. The two insurance schemes for compensating for natural disasters caused by climate change in Italy are the National Solidarity Fund and the Joint Reinsurance Fund. In Italy, the Disaster Risk Reduction Insurance project was launched due to Italy's high vulnerability to climate change and the lack of awareness of climate change among businesses [9].

- The potential of Turkey in the occurrence of large-scale natural disasters, especially earthquakes and volcanoes, and turning it into a financial and social issue for the Turkish government led to the establishment of a natural disaster insurance fund in Turkey. This fund was established to provide earthquake coverage at an affordable rate, limiting the government's financial exposure to natural disasters, creating long-term reserves for catastrophic events to finance future earthquake damages, and encouraging risk reduction. Also, among other actions of Turkey, climate risk modeling initiatives of insurers include the design of pricing and insurance approaches based on risk assessment [10].

- After high-risk natural disasters, except for research funds, Finland has experienced the slightest need for EU funds to finance the reconstruction of buildings and infrastructure, and there has yet to be an incident that requires extraordinary national funds. Before 2014, Finland operated a government-funded flood insurance program. Only private sector insurance companies pay damages to finish municipalities, private individuals, and businesses, depending on the type of property insurance taken out. Insurance coverage in Finland is only provided against damage caused by storms, floods, and hail. If Finland is exposed to natural disasters and insurance companies cannot cover the damage, this country can ask for help as a member of the European Union. In Finland, there is no government scheme for compensation, but if the recovery costs after a natural disaster exceed the budget of private companies, the government grants funds [11].

- Flood cover in Malaysia for households is only available on home insurance as a standard cover and on car insurance with an additional premium. Apart from floods, these insurance policies also cover damages caused by risks such as fire, lightning, and storms. Designing a flood risk map and flood insurance rate map using geospatial technology for relief measures is another risk management strategy in Malaysia [12, 13].

- New Zealand is particularly prone to hurricanes, volcanic events, earthquakes, and landslides. The Earthquake Commission, introduced in 1993 under the Earthquake Commission Act, is the primary source of natural disaster insurance for residential property in New Zealand and covers catastrophic damage to residential property. The Insurance Association of New Zealand was established in 1895 to provide industry representation for fire and general insurance. The increase and the effects of natural disasters in New Zealand from 1895 led to extending the duties of the Insurance Association of New Zealand and considering flood insurance [14].

- China is trying to include climate change risk insurance in global and national climate change adaptation strategies by promoting and strengthening research on this insurance. The role of China's insurance industry in facing climate change includes risk sharing and preparing for the economic losses of the affected residents, providing economic security for households,

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reducing the government's financial burden, preventing and reducing losses, providing information services, and risk management training [15].

- Canadian insurers' standard is that if there are insurable natural disasters, they should be covered by the private market. Coverage in the Canadian market for climate and earthquake risks is generally affordable except for floods, which are excluded from standard household policies. On the other hand, commercial flood risks can be covered under high-risk insurance policies. Other actions of Canada are cooperation between the Financial Institutions Supervision Department and the Insurance Office of Canada in the field of publishing earthquake measures to be able to face the maximum possible damage due to an earthquake and set up a fund to respond to natural disasters with the aim of climate change adaptation related to the national program [16].

- The German Committee for Disaster R*eduction* (DKKV) is Germany's largest disaster risk reduction platform. It has promoted prevention and disaster risk reduction in science, practice, and politics since the beginning of the international decade for natural disaster reduction in 1990. Since 1991, an insurance plan to cover extreme weather events and natural hazards, known as NatCat, has become the standard form of natural hazard insurance for houses and other buildings. Such policies cover losses caused by storms and hail. Coverage against extreme weather events such as floods, earthquakes, torrential rain events, avalanches, landslides, and subsidence is voluntary and is concluded as a supplementary policy. In Germany, flood insurance is provided privately and as a package, which includes other natural hazards and is optionally available to policyholders as part of standard policies for residential owners [16, 17].

- In the United States of America, climate stressors are placing a more significant financial burden on federal and local governments. Fair access to insurance requirements and hurricane plans are generally mandated by the US government and administered by insurers. Most insurers must provide insurance to those unable to obtain it through the voluntary market, which involves various combinations of public funding and government allocation. Among these countries' actions in risk management are the National Flood Insurance Program to reduce flood damage and the climate risk carbon initiative of the California Insurance Department to recognize possible financial risks for insurance investors in oil, coal, and gas[1].

- Mexico has developed a set of mitigation and adaptation measures consistent with the vision of Mexico's National Climate Change Strategy. It has also developed risk transfer solutions to meet climate change adaptation needs, supported pilot projects to apply insurance-related solutions, and cooperated with scientific and financial institutions to develop risk transfer solutions and identify and promote casualty reduction measures for climate-related events. The index-based insurance program is offered in this country for disaster risk and targets poor farmers [18].

Materials & Methods

This research is applied, and its strategy includes a combination of documentary and mixed exploratory studies. To present climate change underwriting methods, the review of written documents and documented experiences in the field of plans and strategies used in developed and developing countries were used, and the country in question was selected according to the access to its information. Finally, the method of field study and distribution of questionnaires was used to understand the

[DOI: 10.22034/ECOPERSIA.12.2.5]

Table 1) The questionnaire's questions about climate change underwriting by insurance companies in Iran.

Code	Question
Demographic characteristics	
Q1	Gender Options: female/male
Q2	Level of Education Options: diploma/associate degree/bachelor's/M.Sc./Ph.D. and above
Q3	What is your current job title in the insurance industry?
Q4	What is the name of your insurance company/institution?
Q5	How much experience do you have in the insurance industry? Options: less than 5 years / 5 to 10 years / 10 to 15 years / 15 to 20 years / 20 years and above
Underwriting	
Q6	Does your company anticipate that the risks caused by climate change (physical, transitory, liability) will affect the underwriting? Options: Yes/No
Q7	To what extent do your company's risk management activities include climate change risks? Options: does not include climate change risks / has a slight connection with climate change risks / has a moderate connection with climate change risks / has a high connection with climate change risks
Q8	Does your company empower its employees regarding climate change factors? Options: yes by recruiting expert employees/ yes by training employees/ yes by recruiting expert employees and training employees/ yes other methods/ no
Q9	Does your company have a dedicated individual or team responsible for strategic climate change management? Options: Yes/No
Q10	Does your company plan to assess, reduce, or mitigate greenhouse gas emissions? Options: Yes/No
Q11	What methods are used by your company to reduce, mitigate, or transfer the risk of climate change? Options: traditional reinsurance / alternative methods of risk transfer / advanced analysis/ cooperation with insurers/others
Q12	Does your company plan to reassess climate change risks and respond to related risks regularly? Options: Yes/No
Q13	Has your company considered the implications of climate change for all of its investment classes (e.g., equities, fixed income, infrastructure, real estate.)?
Q14	Has your company provided incentives such as product price reductions, financial assistance, training, and pre-warning to policyholders to reduce damages caused by climate change? Options: Yes/No
Q15	Which market participants and stakeholders is your company involved in managing climate risk and providing risk transfer/insurance products and services to customers? Options: direct insurers/reinsurers/insurance agents and brokers/other insurance and risk management service providers (e.g., loss adjusters, catastrophe model vendors, risk mappers, consultants)/insurance and reinsurance associations/insurance regulators/governments/ intergovernmental organizations (e.g., UN missions) / business and industry / civil society organizations (NGOs), academic and scientific community/others
Q16	Do you think your company's actions are sufficient to educate stakeholders about the probable risk of climate change? Options: Yes/No

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Continued Table 1) The questionnaire's questions about climate change underwriting by insurance companies in Iran.

Code	Question
Q17	Has your company used modeling (catastrophe models) to conduct stress tests and climate change risk management? If yes, in what time frame, in what region, and for what risks? If not, state the .reason
Q18	What strategies does your company use to face climate change? Express the share of each as a percentage. Options: natural disaster insurance funds/simulation and modeling operations of natural disasters (effective zoning of wind, flood, coastal, land.)/use of digital maps of natural disasters such as digital flood maps/ Development of insurance products related to climate change (climate tourism insurance, agricultural insurance, green building and equipment insurance, renewable energy insurance, distance-based car insurance, environmental insurance, forecast insurance, weather derivatives, parametric insurance.) / use of parametric and non-parametric analytical techniques to calculate and evaluate risk / annual repricing, risk-based pricing for insurance, and pricing / Effective management, protection, and restoration of ecosystems (e.g., forests, mangroves, coral reefs, floodplains), also known as ecosystem-based adaptation/land use, planning, and effective management / natural disaster prevention and control systems/creation of safe and resilient infrastructure (including improvement and enforcement of building standards) / climate risk insurance facilities (national, regional, or international level) supported only by governments / Others
Q19	Which of your company's activities has significantly changed in the last five years? Express the changes as a percentage of climate change. Options: a) risk management including risk identification (risk search, risk mapping.) / risk assessment (risk assessment, risk measurement, and modeling.) / damage prevention measures (to prevent damage) / measures loss reduction (to reduce loss if it occurs) / investment b) Risk transfer including risk underwriting (e.g., guidelines, pricing, coverage, limits, guarantees, exclusions, other terms and conditions of insurance policies) / loss management/product development/reinsurance and reinsurance insurable securities (e.g., natural disaster bond issues that transfer risks to capital markets) C) other cases
Q20	Which of your company's activities will undergo major changes in the next five years? Express the changes as a percentage of the probable changes for climate change. Options: a) Risk management including risk identification (risk search, risk mapping.) / risk assessment (risk assessment, risk measurement, and modeling.) / damage prevention measures (to prevent damage) / measures damage reduction (to reduce damage if it occurs) / investment b) Risk transfer including risk underwriting (e.g., guidelines, pricing, coverage, limits, guarantees, exclusions, other terms and conditions of insurance policies) / loss management/product development/reinsurance and retrocession insurable securities (e.g., natural disaster bond issues that transfer risks to capital markets) C) other cases
Q21	Does your company use climate change data in its premium analysis and determination? Options: Yes/No

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situation of Iran's insurance industry in terms of climate change insurance. Because in this research, a questionnaire tool is used to investigate the climate change underwriting in Iran, the experiences of global surveys are used to set the questions, which will be discussed in the following. The experiences of global surveys include questions based on the exposure of the American insurance industry, the climate change survey of the Bermuda monetary authority, the global survey of the financial plan of the United Nations Environment Program, and the insurance survey of the Scandinavian region.

a) Questioning the US Insurance Industry with Climate Change

The Climate Risk Disclosure Survey report includes a survey process that examines the level of exposure of US insurers to climate change. In this process, which started in 2010 and was presented in 2020, 1000 insurers have completed the relevant questionnaire. The questions of this survey include eight items, some of which have variables, as well as examples and reasons for the positive or negative answers of the respondents. The first item mentioned in the survey is that the insurers are asked if the company has a plan to evaluate, reduce, or alleviate the emission of greenhouse gases. The second item mentioned in the survey is that insurers are asked if the company has a climate change policy concerning risk management and investment management. The third item mentioned in the survey is that insurers are asked to describe their company's process for identifying risks related to climate change. The fourth item mentioned in the survey is that insurers are asked to summarize the current or anticipated risk that climate change creates for the company. The fifth item mentioned in the survey is that insurers are asked if the company has considered the effects of climate change on its investment portfolio. The sixth item of the survey considers the steps taken by the company to encourage policyholders to reduce losses caused by events affected by climate change. The seventh item of the survey is about the steps that the company has taken, if any, to interact with critical areas on the issue of climate change. The eighth item mentioned in the survey focused on the measures taken by the company to manage the risks that climate change has created for the business, and the insurers were asked to describe the use of computer modeling in this field in general [19].

b) Bermuda Monetary Authority Climate Change Survey

The Bermuda Monetary Authority's climate change survey report in 2021 focuses on the Bermuda insurance industry. The content of this report is the result of an analysis carried out by the Bermuda *Monetary Authority* on climate change data through a 2020 survey of insurance groups, commercial insurers, and selected particular purpose insurers. This survey is presented in five categories: a general understanding of climate change risk, insurance, product development, investment, stress testing, and disclosure [20].

c) Global Survey of the United Nations Environment Program's financial plan

The 2013 United Nations Environment Program (UNEP) global financial plan survey aims to use the experience and expertise of the insurance industry in risk management and risk transfer to present the information of insurance organizations to the framework of the United Nations Convention on Climate Change (UNFCCC) on how to use insurance to help the most vulnerable countries against climate-related losses. Respondents to this survey span a wide range of countries, organizations, and functional responsibilities, and its findings can help leverage the risk management expertise and resources of the global insurance industry to build resilient societies and economies against climate

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change and natural disasters [21].

d) Scandinavian Region Insurance Survey on Climate Change

The Scandinavian Region insurance survey regarding climate change was presented in 2009 to create the best guidelines for dealing with climate change and its consequences in the Scandinavian region for insurers. It includes the results of a survey conducted by four Scandinavian region insurance companies (Denmark, Sweden, Norway, and Finland) regarding climate change in the insurance sector. The survey is carried out in six groups of analysis, cooperation with stakeholders and policyholders, imposing requirements on investors, investment within organizations, and designed reports [22].

The questions and categories in the above surveys helped design the questionnaire questions about climate change underwriting

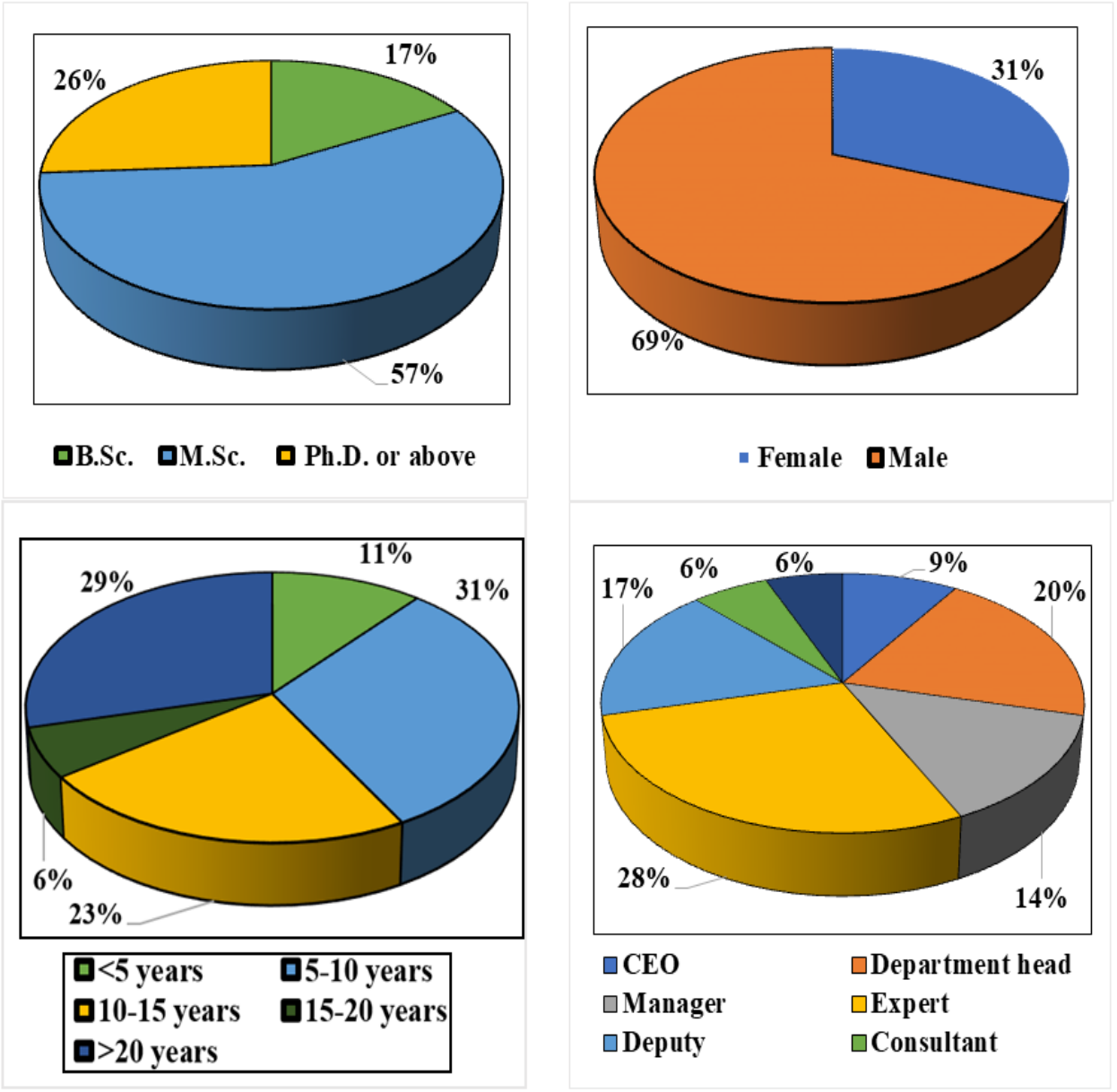

Figure 1) Demographic characteristics of the sample.

Note: The respondents to the questionnaire were selected purposefully and non-probably, and the selection was based on their deep understanding of the subject under study and their participation in the climate change risk management process. Finally, 35 experts filled out the questionnaire.

[DOI: 10.22034/ECOPERSIA.12.2.5]

Table 2) Summary of answers given to question 15.

Market participants and stakeholders	The connection percentage of insurance companies
Direct insurers	66%
Reinsurers	78%
Insurance agents and brokers	49%
Insurance and reinsurance association	29%
Insurance regulators	43%
Governments	20%
Intergovernmental organizations	17%
Business and industry	14%
Civil society organizations (non-governmental organizations), academic and scientific society	14%
Other providers of risk management and insurance services	20%
Other cases: software suppliers	3%

Note: Question Q15 is listed in Table 1.

by insurance companies in Iran.

The Questionnaire

The mentioned questionnaire was compiled and finalized using the results of the above four global surveys and experts' opinions. The respondents to the questionnaire were selected purposefully and non-probably, and the selection was based on their deep understanding of the subject under study and their participation in the climate change risk management process. Finally, 35 experts filled out the questionnaire. The reliability value of the questionnaire using Cronbach's alpha index in SPSS software was equal to an acceptable value of 0.8. The opinions of 14 experts were used to calculate validity, and the values of the content validity ratio and content validity index were equal to acceptable values of 0.92 and 0.95, respectively, through the *Lausche method* and the *Waltz and Basel equation*. The questionnaire is presented in (Table 1).

Findings

Analysis of the questionnaire results

a) Demographic characteristics

To analyze the descriptive statistics of the questionnaire, first, the demographic characteristics of the respondents, including the variables of gender, education level, insurance company/institution, place of work, job title, and history of activity in the insurance industry (Q1 to Q5) have been examined. An attempt was made to complete the questionnaire on average from each insurance company in Iran. The results are shown in (Figure 1).

b) Underwriting Predicting the impact of climate risks on the insurance process in insurance companies

The results of this question show that most insurance companies predict the impact of physical, transition, and liability risks of climate change on their underwriting (Q6). Examples of predicting the impact of climate risks on the insurance process in insurance companies in Iran include the following:

1. Observing the impact of climate change risks on the underwriting of insurance companies: Issuance of coverage related to the limit of compensation and deductible, changes in the pricing of insurance policies, especially fire insurance premiums, increase or change in demand for existing coverage,

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the need to create new coverage, limitations created in the formulation of insurance policy conditions, increase in insured property losses due to the increase in the occurrence of natural disasters.

2. Observing the impact of climate change risks on the insurance process of insurance companies: Issuance of coverage related to the limit of compensation and deductible, changes in the pricing of insurance policies, especially fire insurance premiums, increase or change in demand for existing coverage, the need to create new coverage, limitations created in the formulation of insurance policy conditions, increase in insured property losses due to the increase in the occurrence of natural disasters.

The empowerment of insurance company employees to climate change factors

The relationship between insurance risk management activities and climate change risks was categorized into four sections: high communication, moderate communication, low communication, and non-communication (Q7).

The results of the empowerment of insurance company employees to climate change factors show that about two-thirds of insurance companies empower their employees to climate change factors (Q8). One-third of the companies also announced that they had no plans to empower their employees to climate change factors, and some have stated in justifying their negative response that there was no need for this. Empowerment options include training employees, attracting professionals to train employees, and other methods, including reporting on climate change and strategies for transferring the risk to employees and formulating strategies tailored to these changes.

The specific person or team responsible for the strategic management of climate change

The analysis of the results regarding the specific person or team responsible for the strategic management of climate change shows that some insurance companies need a dedicated team for this purpose (Q9).

It should be noted that those insurance companies that answered positively to this question declared that this person or team is the same unit of risk management, plan, and development management, and technical assistance, which, in addition to managing various risks, is also active in this field. Therefore, the company needs to have a team dedicated to climate change.

The reasons for the absence of a dedicated team or person in insurance companies, according to the results obtained, are:

1. Company policies: Several insurance companies believe the current insurance market can be created without a dedicated unit. In addition, their companies have specialized and technical teams for risk management at a strategic level, which includes climate change risk management. In general, strategic climate change management is placed on the agenda of teams and committees in cases where it is relevant.

2. Existing limitations: Non-acceptance of climate change despite its significant importance, lack of sufficient expertise in this field, and the need for particular conditions and permission from upstream institutions to create a dedicated team.

The summary results of questions Q6 to Q9 are shown in (Figure 2).

The programs to assess, reduce, or mitigate greenhouse gas emissions in the company

Regarding programs to assess, reduce, or mitigate greenhouse gas emissions in the company, summarizing the answers indicates that only about a quarter of insurance companies have such programs, and some do not, although a number of them said that they might put these programs on their company's agenda this year (Q10).

[DOI: 10.22034/ECOPERSIA.12.2.5]

Table 3) Summary of answers given to question Q18.

Strategy	Percentage of strategy selection (%)	The mean share of each strategy (%)
Natural disaster insurance funds	49	10
Simulation and modeling of natural events (effective wind, flood, coastal, land zoning.)	26	14
Using digital maps of natural events such as flood digital maps	26	17
Development of insurance products related to climate change (climate tourism insurance, agricultural insurance, green building and equipment insurance, renewable energy insurance, distance-based car insurance, environmental insurance, forecast insurance, weather derivatives, parametric insurance.)	34	14
Using parametric and non-parametric analytical techniques to calculate and evaluate risk	40	28
Annual repricing, risk-based pricing for underwriting and pricing purposes	54	43
Effective management, conservation, and restoration of ecosystems (e.g., forests, mangroves, coral reefs, floodplains), also known as ecosystem-based adaptation	6	10
Land use, effective planning, and management	14	12
Natural disaster prevention and control systems	26	21
Creating safe and resilient infrastructure (including improving and implementing building standards)	9	7.5
Climate risk insurance facilities (national, regional, or international level) supported only by governments	6	10
Other cases: communication with other companies that have experience in this field	3	10

Note: Question Q18 is listed in Table 1.

Insurance companies' programs to assess, reduce, or mitigate greenhouse gas emissions include:

1. Providing incentive plans and developing electronic services and reducing paper consumption: Recommending and encouraging policyholders to comply with the relevant points, changes in the way resources are used, changes made in the insurance process along with the progress of the digital sector, and the development of electronic insurance (both reduction and elimination of providing the insurance policy in a physical form and therefore online issuing the insurance policy and assessing the damage through online applications) and cooperating with companies that produce technologies that reduce pollution and greenhouse gases.

1. Also, among the reasons for not providing insurance companies with a program to reduce, relieve, or evaluate greenhouse gases is the need for sufficient awareness in this field and the lack of placing this issue in the company's priorities. Some insurance companies also believe that providing such programs is outside the scope of their duties and the insurance industry's general.

The transfer of the risk of climate change

In this question, the respondents were asked to comment on the methods used in their company to reduce, mitigate, or transfer the

[DOI: 10.22034/ECOPERSIA.12.2.5]

risk of climate change and choose among the options of traditional reinsurance, alternative methods of risk transfer, advanced analysis, and cooperation with insurers and if they use other methods, mention it (Q11). Summarizing the responses indicated that 9% of insurance companies do not use any specific method to reduce, mitigate, or transfer climate change risk. Concerning other methods, it is possible to mention the use of aggregate portfolio by the insured and the purchase of insurance policies in the form of packages in different fields and electronic services.

The review of regular and re-evaluation programs of climate change risks

The results of the review of regular and re-evaluation programs of climate change risks and response to related risks in companies show that several insurance companies have programs in this regard, and a number of them either do not have a program or are not aware of the existence/non-existence of such programs. Some mentioned they are looking for measures in this regard (Q12). These programs are:

1) Risk management: Carrying out specialized and continuous studies to identify types of climate risks and their effects on the insurance industry, periodic reports summarizing catastrophic risks in the risk committee, and periodic identification and assessment of climate risks in the risk management department and reliance units, planning and periodic assessment to cover normal risks for an entire city or entire village according

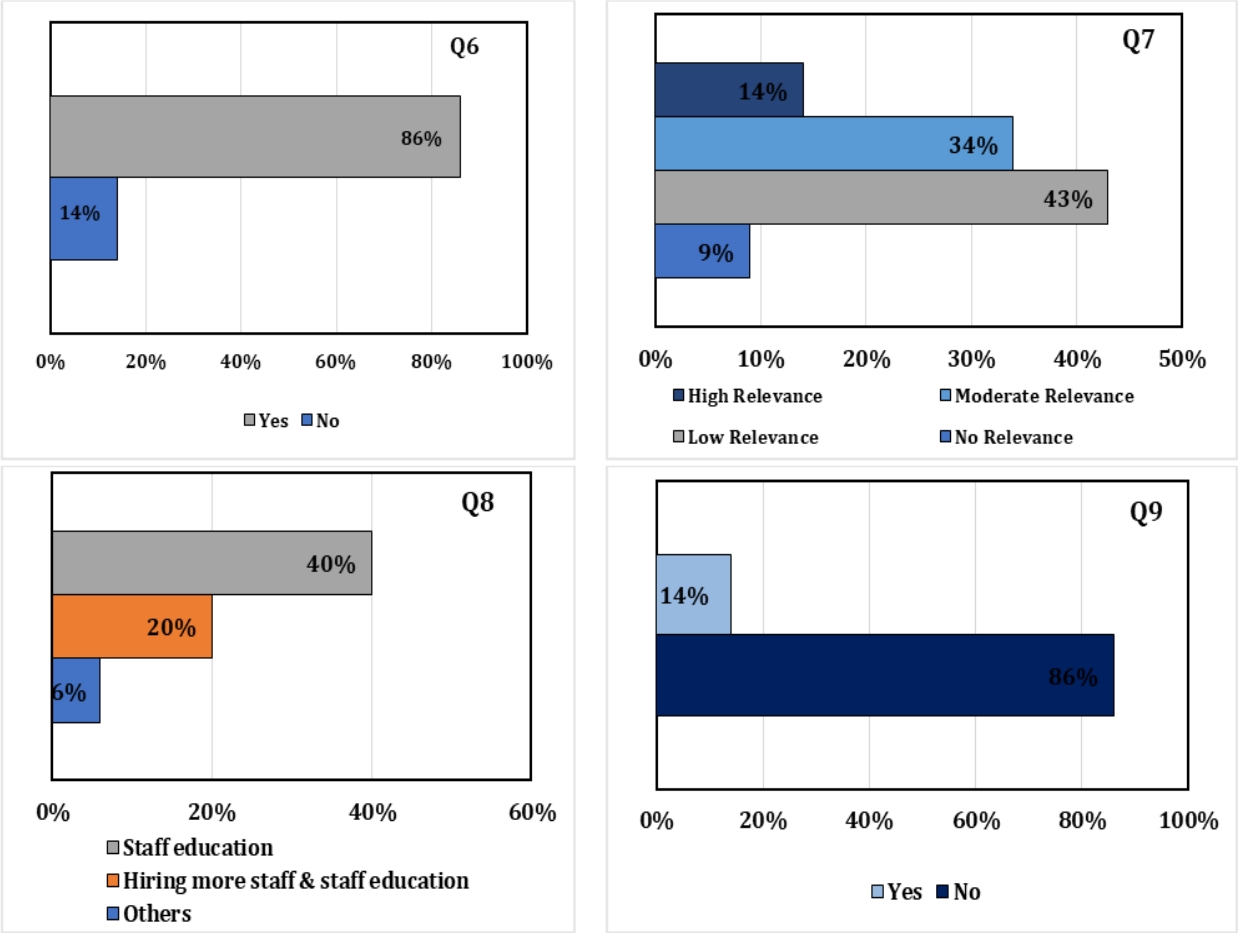

Figure 2) Results of the insurance process and the empowerment of employees to climate change factors.
Note: Questions Q6 to Q9 are listed in Table 1.

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to the request of municipalities and rural districts, annual monitoring and assessment of climate change risks by the planning and development management and recording these effects in the upstream documents of the company, which causes the entry and impact of these changes on the annual operational plans of the company have been established a communication system with other units through the risk management department to inform the identified risks to other units and thus make them aware of the reduction of damages caused by climate change.

2) Damage management: Developing sales and damage plans for each field and each province and defining related measurement indicators, such as the change in the number of damage occurrences in each province in recent years.

3) Other underwriting activities include revising insurance policies where the climate change phenomenon may need more attention and re-actuarial in some insurance fields.

To consider the consequences of climate change for all their investment classes

Examining the answers regarding whether the companies have considered the consequences of climate change for all their investment classes shows that some insurance companies have not (Q13). However, several companies have paid attention to this.

Examples of insurance companies paying attention to the consequences of climate change in all investment classes include the following:

1. Risk analysis and identification: Predicting the risks of natural disasters, including damage to the company's assets and property and injury to employees at the time of identifying the operational risks of the company, identifying the damages caused by climate change as an investment risk in the real estate sector, as well as in the company's stock section, a detailed analysis of the current and future situation in all stages of investment decision-making, paying attention to this issue at the time of risk acceptance.

2.The summary results of questions Q10 to Q13 are shown in (Figure 3).

The incentives of the company to reduce the damages caused by climate change

The summary of the results on whether the company has provided incentives such as product price reduction, financial aid, training, and early warning. To the policyholders to reduce the damages caused by climate change shows that several insurance companies have provided incentives to reduce the damages caused by climate change to policyholders, such as product price reduction, training, and warnings. The answers to some others to this question were either negative or that they needed more information in this regard. However, some announced they would provide incentives to their insurance company soon. The summary result of question Q14 is shown in (Figure 4).

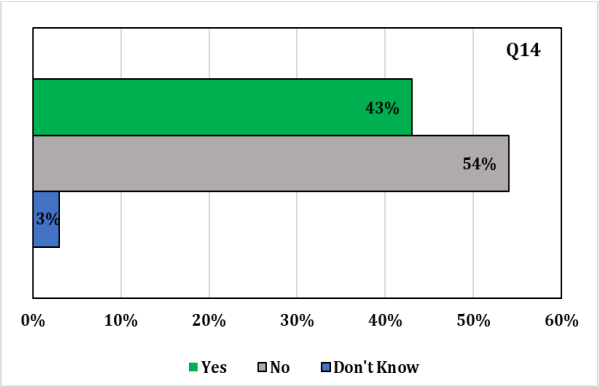

Figure 4) The companies' response to reduce damages caused by climate change.

Note: Question Q14 is listed in Table 1.

Incentives provided by insurance companies include:

1. Pre-warning: Providing pre-warning and corrective comments when issuing insurance policies.

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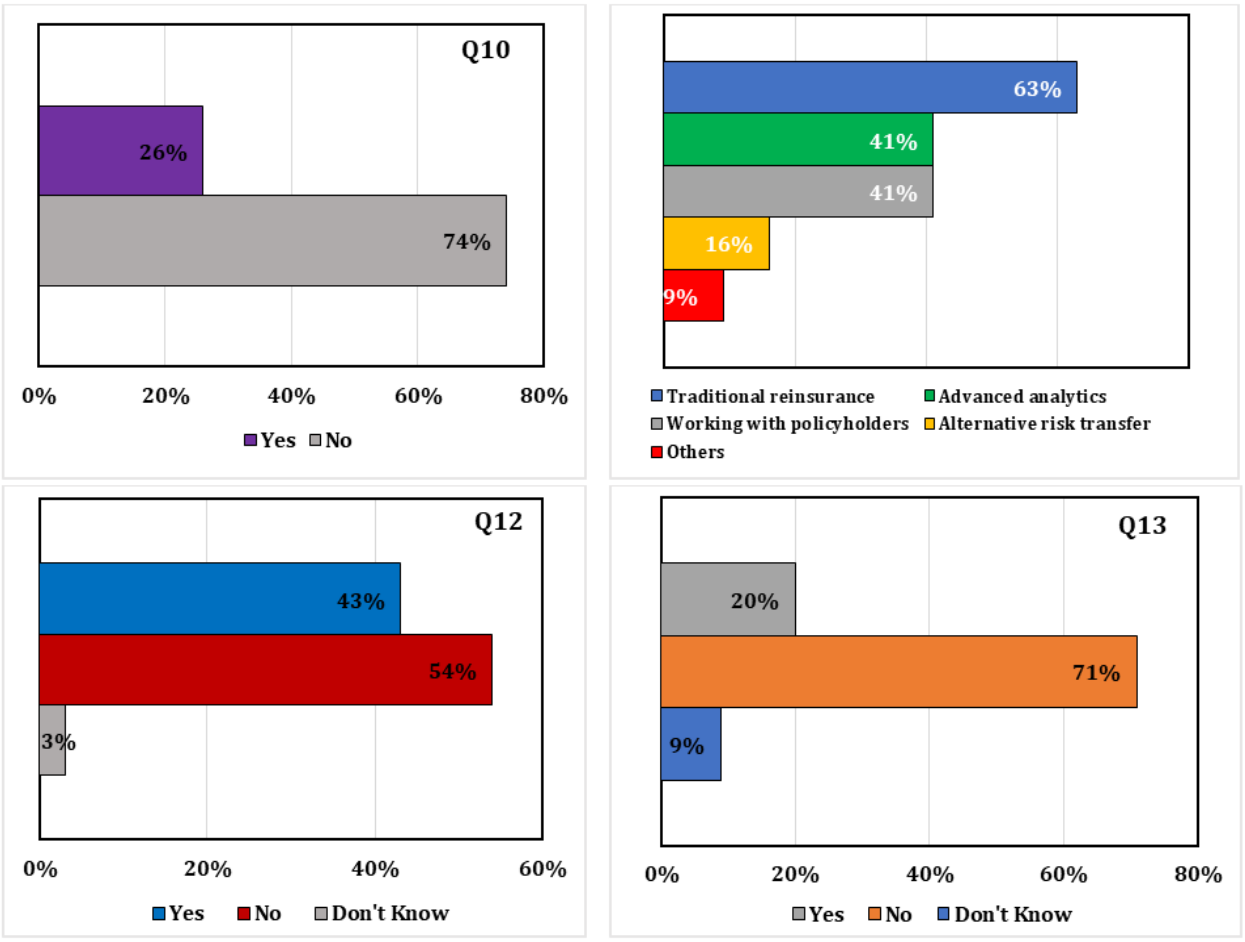

Figure 3) Summary of answers given to questions Q10 to Q13.
Note: Questions Q10 to Q13 are listed in Table 1.

2. Advice and training to policyholders: Provide written safety recommendations to policyholders by an expert during the initial visit, and provide safety recommendations (regarding the type of structure) if necessary (records of natural disasters) in fire insurance. Providing recommendations and solutions from the reports from trusted experts to insurers and providing advice to insurers regarding using "Internet of Things" innovations in residential homes and factories and other fire and flood warning devices.
3. Incentive plans: Offering discounted products in the field of climate change to policyholders, improving the capacity of the sales network to become more familiar with climate change, attracting policyholders through advertising and information, planning to provide micro-insurance products and insurance coverage according to the needs of policyholders to encourage more people to buy coverage for the events caused by climate change.

The company's relationship with market participants and stakeholders

In this question, the respondents were asked to comment on their company's relationship with market participants and stakeholders involved in climate change risk management and providing risk transfer products and services to customers and choose from the options in (Table 1) (Q15). They were also asked to mention if they considered other cases. The analysis of the results showed that 91% of the insurance companies are in contact with the participating participants and beneficiaries

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Table 4) Summary of answers given to question Q19.

The changes	The percentage of changes made	The mean share of climate change in the changes made (in percent)
Risk identification (risk search, risk mapping.)	63	23
Risk assessment (risk investigation, risk measurement, and modeling.)	69	29
Loss prevention measures (to prevent loss)	34	14
Loss reduction measures (to reduce loss if it occurs)	43	17
Investment	20	24
Risk underwriting (e.g., guidelines, pricing, coverage, limits, warranties, exclusions, and other policy terms and conditions)	63	27
Loss management	34	14
Product development	37	36
Reinsurance and retrocession	51	26
Insured securities (for example, natural disaster bond issues that transfer risks to capital markets)	11	16
Control of catastrophic risk accumulation	3	100

Note: Question Q19 is listed in Table 1.

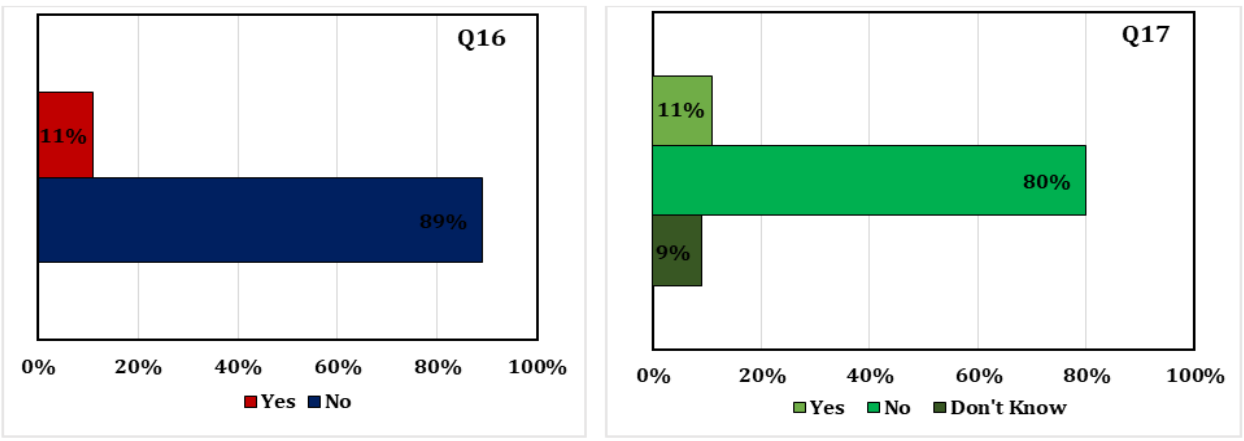

Figure 5) Summary of answers given to questions Q16 and Q17.
Note: Questions Q16 and Q17 are listed in Table 1.

mentioned in (Table 2), and the percentage of each is expressed separately. In addition, 9 percent of insurance companies also stated that they have no connection with participants and stakeholders of the participating market in the field of climate risk management.

Analysis of the results of question Q16

In response to this question, most

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Table 5) Summary of answers given to Q20.

Probable changes	Percentage selection of probable changes (%)	The mean contribution of climate change to probable changes (%)
Risk identification (risk search, risk mapping.)	69	17
Risk assessment (risk investigation, risk measurement, modeling.)	63	27
Loss prevention measures (to prevent loss)	63	22
Loss reduction measures (to reduce loss if it occurs)	49	19
Investment	43	15
Risk underwriting (e.g., guidelines, pricing, coverage, limits, warranties, exclusions, and other policy terms and conditions)	66	23
Loss/Damage management	54	19
Product development	69	31
Reinsurance and retrocession	63	20
Insured securities (for example, natural disaster bond issues that transfer risks to capital markets)	46	25
Re-actuarial of insurance rates according to climate changes in the fields of fire and liability	3	-

Note: Question Q20 is listed in Table 1.

respondents believed that more than the measures taken in their company to educate the stakeholders about the possible risks of climate change are needed.

The reasons for the inadequacy of these measures include the limitations, such as the lack of adequate and advanced measures in this field and the need for a more specialized and effective investigation, the lack of acceptance and understanding of climate change among insurance companies, the broad consequences of this phenomenon, and the need to examine new aspects of covering, training or making changes in the insurance process and not examining the effects of climate change in various insurance fields, including life insurance.

Analysis of the results of question Q17

Regarding whether the company has used modeling (catastrophe models) to perform stress tests and climate change risk management, most insurance companies either do not use modeling to perform stress tests and climate change risk management, or they mentioned the need for more knowledge. However, a small percentage of insurance companies have used modeling. Insurance companies that used modeling provided the following responses:

1. Conducting research in modeling and pricing the risk of earthquake swaps and bonds in recent years and deciding to implement them.
2. Using modeling after starting work and accepting risk from the market based on geographical area patterns.

The summary results of questions Q16 and Q17 are shown in (Figure 5).

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Analysis of the results of question Q18

In this question, the strategies of insurance companies in facing climate change were investigated, and the respondents were asked to choose the strategies they use among the options in (Table 1) (Q18) and to name them if they use other strategies. The analysis showed that 89% of insurance companies use different strategies to face climate change, and 9% of them do not use a strategy. However, some companies announced they are considering and implementing different strategies soon. The results of applying the strategy are described in (Table 3), in which the strategies, the percentage of strategies selected by the insurance companies, and the average share of each strategy.

Analysis of the results of question Q19

In this question, the significant changes in the activity of insurance companies in the last five years were asked, and the respondents were asked to choose their desired changes among the options in (Table 1) (Q19) and to name them if they had any other changes. Summarizing these results showed that the activity of 91% of insurance companies has changed in the last five years. Some 9% of the companies also declared that they have stayed the same in the last five years. The analysis of these changes is described in (Table 4), in which the changes made and the percentage of selection of these changes by insurance companies, as well as the average share of climate change in the changes made, are stated:

Analysis of the results of Question Q20

In this question, possible and significant changes in the activities of insurance companies in the next five years were questioned. The respondents were asked to choose their desired changes from the options in the table below and name them if they considered other possible changes. The results of the analysis indicate that the activity of 94% of insurance companies will undergo probable changes in the next five years. 6% of the companies also announced that they will not have any possible change in their activities in the next five years. The summary of the results of the possible changes in the activities of insurance companies in the next five years is described in (Table 5), in which the possible changes and the percentage of choosing these possible changes by the insurance companies, as well as the average share of climate change in the possible changes, are stated.

Analysis of the results of question Q21

Based on the results, as shown in (Figure 6), less than half of the insurance companies use climate change data in their analysis and premium determination, and more than half do not. However, some insurance companies said they would include this issue in their plans.

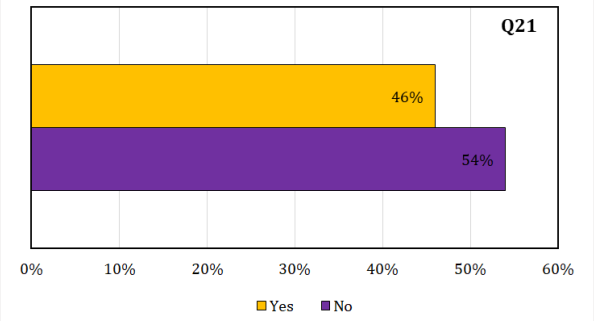

Figure 6) Summary of answers given to Q21.
Note: Question Q21 is listed in Table 1.

The cases of using climate change data in the analysis and determination of insurance premiums are:

1. Risk analysis: Calculating and analyzing risk and determining the premium rate annually through statistics and climate change data.
2. Issuance of insurance policy: Issuance of insurance policies, including fire, engineering, and oil and energy, by storing data in specialized panels.
3. Analysis of losses: A review of records

[DOI: 10.22034/ECOPERSIA.12.2.5]

of accidents that occurred due to climate change and related statistics, including subsidence accidents; review of reports from trusted experts in the insured areas; and paid losses of natural disaster coverage and fire insurance policies against the premiums received on an ongoing basis.

Conclusion

Using insurance mechanisms and applying insurance processes is essential for countries to deal with climate change risk and its management.

This research investigated the experiences of selected developed and developing countries regarding insurance mechanisms and insurance processes' use. This study aims to develop and adapt them to the current situation in Iran. The experiences of global surveys regarding climate change were investigated to design a questionnaire and to understand the situation of Iran's insurance industry in the climate change insurance process.

According to the research results, several insurance companies in Iran have observed and predicted the impact of climate change on their insurance processes, especially the impact on the pricing of insurance policies, especially the fire insurance premium, the increase or change in demand for existing coverage, and the increase in insured property losses due to the increase in the occurrence of natural disasters.

Categorizing the relationship between risk management activities in insurance companies and climate change risks into four levels of no relationship, little relationship, medium relationship, and high relationship showed that only some insurance companies believe in the impact of climate change risks and consider it in their risk management.

The issue of empowering the employees of insurance companies and training specialized personnel should be taken into the attention of the insurance industry as a requirement in climate change risk management, which is currently done in two-thirds of the insurance companies and primarily through training employees or recruiting specialists. On the other hand, considering that the strategic management of climate change requires monitoring and evaluating the opportunities and challenges created according to the strengths and weaknesses of the company, the presence of a dedicated person or team in insurance companies that is responsible for climate change risk management it is essential that, unfortunately, the formation of this specialized team has not been considered in the country's insurance companies. The statistics regarding the emission of greenhouse gases show that Iran ranks seventh among the countries producing greenhouse gases in the world. Therefore, developing and implementing programs to evaluate, reduce, or mitigate greenhouse gas emissions by insurance companies is essential.

Investigations showed that traditional reinsurance methods, advanced analysis, cooperation with insurers, and alternative risk transfer methods are among the methods used in Iranian insurance companies to reduce, relieve, or transfer climate change risk, respectively. By examining the countries, the results showed that the most critical risk transfer tools were actuarial methods, reinsurance, weather derivatives, parametric insurance, takaful, and funds. Considering that Iran is among the top 10 countries in the world in terms of occurrence of natural disasters, every insurance company must have plans to regularly re-evaluate risks related to climate change and respond to related risks. About half of the country's insurance companies have plans for regular re-evaluation of climate risks, including risk management (periodic identification and evaluation of climate risks and natural

[DOI: 10.22034/ECOPERSIA.12.2.5]

disasters), damage management, and revision of insurance policies and re-actuarial of some insurance fields. Climate change imposes different levels of physical and transfer risks on the assets and liabilities of insurance companies and, therefore, has consequences on their investment classes that should be considered. Since providing all kinds of incentives to policyholders can help manage climate change as well as possible and reduce its losses, insurance companies should consider incentive programs in their activities. Currently, almost half of the country's insurance companies, through early warning, counseling, training, advertising, and information, selling discounted products, and planning to provide new products, especially micro insurance products and related coverages, to encourage more people to buy coverage for accidents caused by climate change has provided incentives to insurers, which should be further developed and expanded. In recent decades, many experts in the insurance industry have been looking for a solution to deal with climate change and the resulting damages in different regions of the world. However, the damage is so extensive in some cases that the insurance industry cannot compensate for it. However, this industry has emphasized its role in dealing with the threats of climate change and reducing the damage it causes. Most of the country's insurance companies use different strategies to deal with climate change, of which annual repricing and risk-based pricing have been the most popular. Use of natural disaster insurance funds, parametric and non-parametric analytical techniques in risk calculation and evaluation, development of insurance products related to climate change, natural disaster prevention and control systems, simulation and modeling of natural disasters, use of digital maps of natural disasters, land use, creating safe infrastructure, climate risk insurance facilities, and protection and restoration of ecosystems are placed in the following categories, respectively.

This paper investigated the role of underwriting in climate change risk management. Future research could discuss the development of insurance products under climate change and examine international experiences.

Funding: This research is not supported.

Conflicts of interest/Competing interests: Not applicable

Ethics approval/declarations: Not applicable

Consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and material/ Data Availability: All data generated or analyzed during this study are included in the text of the article (and its supplementary information files).

Code availability: Not applicable

Authors' contributions:

A Hamzeh, MR Farzaneh, F Banimostafaarab, and MJ Khordadi designed the questionnaire and reviewed the manuscript. They also performed the questionnaire analysis and conducted a comparative study of countries.

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