MODERNISING ACTUARIAL PRACTICE TO ADDRESS CLIMATE CHANGE AND SOCIETAL ISSUES: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Technology, data science, artificial intelligence (AI), climate change, and other societal issues drive a revolutionary period that the actuarial profession must navigate. Actuaries are unusual in that they can tell stories with data, allowing for better understanding and major benefits for business, government, and society at large. Actuaries must adapt to changing times and use new technologies to remain relevant and uphold their trusted advisory function, given the complexity of today's dangers and possibilities. To address urgent problems like climate change and global uncertainty, this research examines how actuaries might use new methods to adapt to this disrupted environment.

This study aims to evaluate the approaches that can fulfill the needs of modern world and determine the best ways to solve societal issues like climate change and demographic transitions while integrating technical advancements like artificial intelligence (AI) and big data into actuarial practice. The study also aims to investigate how actuaries can continue to steer well-informed decision-making processes that influence the future and balance the interests of various stakeholders.

A thorough analysis of the research, case studies from various industries, and a systematic literature reviews using PRISMA used for research approach. The review adhered employed a comprehensive search strategy across electronic databases, including PubMed, Google Scholar, Web of Science, ScienceDirect, Sage Journals, and Emerald, to identify relevant studies published between 2020 and 2024. Studies selected for inclusion involved modernizing actuarial practice in response to climate change and societal challenges, focusing on both randomized controlled trials and observational studies.

The results imply that actuaries can better offer creative answers to contemporary problems when they collaborate with AI, data science, and other emerging technologies. Actuaries also need to continue becoming forward-thinking and adaptable, concentrating on social demands like sustainable development and climate resilience. Actuaries can continue to provide value in a world that is changing quickly if they can turn uncertainty into opportunity, and emphasize the profession's role in creating a resilient future.

Keywords: New age, new actuary, climate change, societal issues.

Introduction

Technology, data science, artificial intelligence (AI), climate change, and other societal issues drive a revolutionary period that the actuarial profession must navigate. Actuaries are unusual in that they can tell stories with data, allowing for better understanding and major benefits for business, government, and society at large. Actuaries must adapt to changing times and use new technologies to remain relevant and uphold their trusted advisory function, given the complexity of today's dangers and possibilities. To address urgent problems like climate change and global uncertainty, this research examines how actuaries might use new methods to adapt to this disrupted environment. In order to assist companies in making well-informed decisions, actuaries are essential in assessing the likelihood and consequences of future occurrences (Iñaki et al., 2021).

However, the necessity for the actuarial profession to update its procedures is becoming more widely acknowledged as global concerns like climate change and societal difficulties become more pressing. Actuaries must modify their techniques and resources to incorporate non-financial elements that affect long-term sustainability and societal well-being in addition to evaluating financial risks in light of climate change, environmental degradation, and social injustices. This change offers actuaries both opportunity and difficulties to broaden their responsibilities and make a more complete contribution to solving global concerns (Walter, 2020).

Climate change has emerged as one of the most pressing issues of the twenty-first century, with significant implications for several companies and society as a whole. Rising sea levels, extreme weather, changing farming methods, and the harmful health consequences of air pollution are just a few of the many and complex threats posed by climate change (Chen et al., 2023). The financial industry, which includes the insurance and pension sectors, is particularly vulnerable to these risks because they must contend with the potential financial ramifications of increasingly frequent and severe climate-related calamities. Actuaries, who are typically thought of as risk assessors, possess the knowledge and skills necessary to estimate these risks and offer suggestions on how businesses may better anticipate and reduce the uncertainties associated with climate change. Actuaries must, however, adopt new approaches that take into consideration the distinct and changing character of climate hazards in order to effectively handle climate change (Aldoseri & Albaz, 2023).

In addition to climate change, actuaries must reevaluate their conventional methods in light of societal challenges including social justice, demographic changes, and inequality. The need for retirement planning and long-term care solutions is growing as populations age, with the percentage of old people in many nations rising. Furthermore, actuaries must take social risks into account when making assessments due to the emergence of social movements calling for increased equality and inclusion in both the public and private sectors. Despite sometimes being overlooked in conventional actuarial models, these societal issues are growing in importance and must be taken into account when making actuarial decisions. In order to ensure that actuarial methods help to create a more sustainable and fair society, the profession must change to take into account not only financial risks but also the wider societal ramifications of its work.

The profession is beginning to see the need of updating actuarial practice to meet these new challenges. The integration of climatic and societal risks in actuarial work is being pushed more and more by regulatory agencies, educational institutions, and business executives (Romero et al., 2023). Since environmental, social, and governance (ESG) considerations are essential for assessing long-term risks, a number of programs have been started to encourage actuaries to broaden their skill sets in this area. In order to ensure that actuaries are prepared to handle the complexity and unpredictability of the modern world, this modernization process entails the creation of new frameworks, procedures, and tools that integrate both quantitative and qualitative data (Cakir et al., 2022).

The best approach for examining how the actuarial profession is changing to address these issues is a thorough literature study. This method enables the discovery of trends, gaps, and new practices in the subject by examining the body of current research. It also makes it possible to fully comprehend the ways in which actuarial practice is now tackling societal challenges and climate change, as well as the obstacles and possibilities for more integration (Chigbu et al., 2023). The main forces for change, the abilities and information actuaries must acquire, and the effects of these developments on the industry at large can all be found in this overview. The actuarial profession must modify its procedures to meet these new difficulties as social concerns and climate change continue to influence the future. For actuaries to continue offering insightful advice on risk management and supporting the more general objectives of sustainability and social justice, actuarial practice must be modernized. The purpose of this study is to examine how modernizing actuarial procedures might be applied to solve social issues and climate change through a methodical literature analysis.

Literature Review
Modernising

The process of updating and changing current procedures, methods, or structures to conform to modern expectations, technological advancements, and social requirements is referred to as modernizing. For many businesses, including actuarial science, modernization is essential to be current and adaptable to a constantly shifting environment. Usually, this change entails implementing new techniques, frameworks, and instruments that take into account knowledge, technological, and

social advancements. Rethinking conventional methods, frameworks, and approaches to problem-solving in order to make them more inclusive, effective, and efficient is another way that modernization may be accomplished (Alojaiman, 2023).

Modernization in actuarial science involves more than just incorporating new software or computational instruments. Actuaries' approach to risk assessment must fundamentally evolve to take into account a wider range of factors, such as societal concerns, climate change, and developing technology. Actuarial models have historically concentrated on financial risks, forecasting future events using statistical models and historical data. However, a more comprehensive and progressive strategy is required to address the complex issues of the modern world, such as the uncertain consequences of climate change, population changes, and socioeconomic inequality. This implies that actuaries need to take into account non-financial elements that affect long-term results in addition to financial concerns (Baldacchino et al., 2024).

Actuarial Practice

The profession and techniques used by actuaries to evaluate, control, and reduce risks mainly in the areas of insurance, pension planning, finance, and investment, are referred to as actuarial practice. Actuaries assess the probability of future occurrences and their financial ramifications using a combination of economics, statistics, mathematics, and financial theory. This frequently entails figuring out reserves, calculating premiums, and creating financial instruments that can assist people, businesses, and governments in efficiently managing risk. The highly specialized field of actuarial practice uses exacting quantitative techniques to comprehend intricate systems and forecast unpredictable future events (Widianto et al., 2024).

Actuarial practice has always placed a strong emphasis on financial risks by modeling future patterns using previous data. Actuaries, for example, have long been in charge of setting insurance policy prices, calculating payments to pension funds, and offering risk management advice. Estimating the financial effect of certain occurrences, such as death, disability, disease, or property damage, using

statistical models and probability is the foundation of actuarial practice. In order to maintain the financial stability of insurers, pension funds, and other financial organizations while offering policyholders and beneficiaries the coverage or payouts they require, predictive modeling is crucial (Cossette et al., 2021).

Climate Change

Long-term changes and modifications to Earth's temperature, precipitation patterns, and other atmospheric variables are referred to as climate change. Although natural processes have a role in climate change, human activity is mostly responsible for the notable and swift changes seen in recent decades. The atmospheric emission of greenhouse gases (GHGs), including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), is the main cause of climate change. Global warming is the term for the phenomena whereby these gases trap heat and raise the average temperature of the world. Deforestation, industrial operations, agricultural practices, and the burning of fossil fuels for energy are all significant causes of the rise in GHGs, which causes significant changes in the patterns of the world climate (Bibi & Rahman, 2023).

Climate change has wide-ranging and complex effects on human society, weather systems, and ecosystems. Sea levels are increasing as a result of melting glaciers and polar ice caps, more frequent and intense heatwaves, and changed precipitation patterns brought on by warming global temperatures. Natural ecosystems and human settlements are under risk from more severe and erratic extreme weather events including storms, droughts, and floods. Climate change has major societal and economic repercussions in addition to these environmental ones, such as upsetting public health systems, food production, and water supplies. Because they frequently lack the infrastructure and means to adapt to these changes, vulnerable populations, especially those in developing nations are disproportionately impacted by the effects of climate change. The potential for climate change to produce feedback loops that worsen the situation is among its most worrisome features (Adnan et al., 2023).

Societal Issues

Societal issues are difficulties or problems that a sizable section of a society faces, frequently affecting the general well-being of social systems as well as the welfare of people and groups. These problems can take many different forms, such as poverty, inequality, healthcare inequalities, educational gaps, discrimination, and environmental degradation. They are caused by a complex interplay of economic, political, cultural, and environmental variables. It is challenging to address societal problems without extensive and systemic changes because they frequently entail deeply ingrained social systems that uphold injustice and inequality. Inequality, which may take many different forms, including gaps in wealth, racial and cultural backgrounds, gender, and access to resources, is one of the most pervasive social problems (Livingston & Reddy, 2022).

Social divides are frequently brought about by these disparities, which restrict possibilities for particular groups and prolong cycles of adversity. For example, systemic obstacles like discrimination and limited access to essential services may result in lower educational attainment, fewer employment options, and worse health outcomes for members of disadvantaged populations. In order to address inequality, substantial work must be put into developing fair policies that guarantee equitable access to healthcare, work, education, and other necessities. Additionally, the social and economic systems that perpetuate disparity must be addressed (Žižek et al., 2020).

Methodology

An evaluation of modernizing actuarial practice to meet social challenges and climate change was done through a systematic study. The study design complied with PRISMA (Preferred Reporting Items for Systematic Reviews), which is a set of recognized principles for systematic reviews. A thorough search plan was developed and put into practice for a variety of electronic databases, such as Pubmed, Google Scholar, WOS, Scient Direct, Sage Journal, and Emerald. Using a mix of keywords and restricted vocabulary phrases associated with "Modernising", "Actuarial", "Practice", "Climate Change", "Societal Issues".
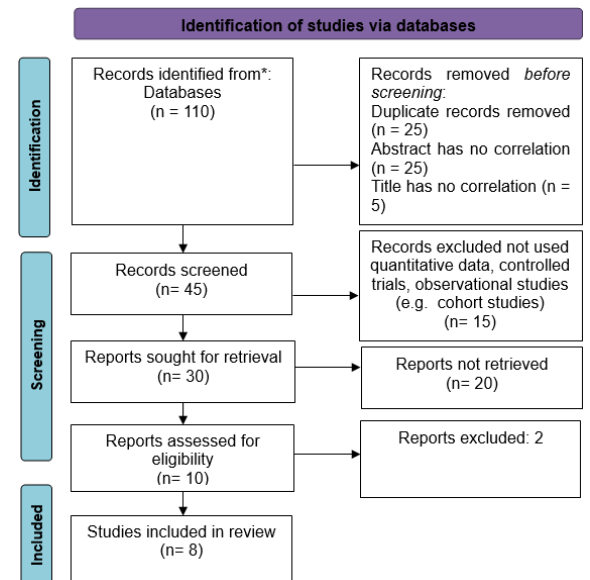

Figure 1. Literature Screening Results

The criteria:
Inclusion Criteria
a. Studies involving modernising actuarial practice to address climate change and societal issues.
b. Type of studies both randomized controlled trials, observational studies (e.g. cohort studies).
c. Studies published in English.
d. Publication date last 5 years will be applied to ensure a comprehensive review of the available literature (2020-2024).

Exclusion Criteria
a. Studies that do not focus on modernizing actuarial practice in relation to climate change and societal issues.
b. Studies that do not involve actuarial practices, such as those outside the field of actuarial science or insurance.
c. Studies not published in English.
d. Studies published before 2020.

Discussion

The previous research concentrate on several ways that actuarial science might be used to address the effects of climate change and other environmental issues. The implementation of mitigation and adaptation strategies for climate change by Brazilian industrial companies is examined by Perlin et al. (2021), who also highlight the benefits of these strategies for business performance and provide a thorough framework for comprehending how climate

change is incorporated into business operations. The usefulness of the Actuaries Climate Index (ACI) in predicting the effects of extreme weather on crop yields and insurance applications is also examined by Pan et al. (2021), who propose that the index could be improved by adding data-driven weights and creating it at higher resolution levels for more accurate projections.

The potential of novel insurance mechanisms in reducing climate change-related catastrophe risks in Latvia is examined by Feofilovs et al. (2024) using system dynamics, highlighting the significance of integrating these mechanisms with disaster risk reduction strategies. In their analysis of the Common Agricultural Policy's implementation in Greece, Kyriakopoulos et al. (2022) demonstrate that despite the nation's severe environmental problems, its strategic framework is in line with European environmental and climate policies, necessitating significant adjustments to national planning.

A thorough road map for attaining green insurance is given by Stricker et al. (2022), who include important actions and performance metrics (KPIs) in a number of areas, including risk management, marketing, and product development. They stress that the insurance sector must take a comprehensive approach to sustainability. In their discussion of the integration of artificial intelligence and big data in actuarial science, Hassani et al. (2020) point out that data analytics is widely used in insurance policy pricing, but they also point out a weakness in cybersecurity risk modeling because of a lack of data. According to their findings, machine learning methods may increase pricing models' accuracy.

In order to adjust to shifting environmental circumstances, Wang et al. (2023) advocate for the inclusion of air quality concerns in risk procedures, focusing on the effect of air pollution risk on crop insurance sustainability. Last but not least, Rokicki and Ostaszewski (2021) assess how well actuarial credibility adjusts cost estimates for transportation infrastructure projects, contending that it performs better than alternative forecasting methods, particularly in situations with limited data. They suggest using it as a quick and easy way to enhance project planning and avoid expense overruns. Collectively, these studies highlight the expanding significance of actuarial science in tackling the intricate relationship between environmental sustainability, commercial success, and climate change.

Table 1. Systematic Review

Name (year)	Title	Metodhology	Result
Perlin et al. (2021)	Climate Change Mitigation, Adaptation Practices, and Business Performance in Brazilian Industrial Companies	Quantitative	Brazilian industrial firms have implemented both climate change adaptation and mitigation strategies, demonstrating the connections between these strategies and many aspects of business performance. This research advances science and creates a theoretical framework that tackles business performance and climate change adaptation and mitigation strategies holistically.

Name (year)	Title	Metodhology	Result
Pan et al. (2021)	Assessing the Effectiveness of the Actuaries Climate Index for Estimating the Impact of Extreme Weather on Crop Yield and Insurance Applications	Linear Regression Model	According to our research, the ACI index shows promise for projecting agricultural yields and determining (re)insurance rates. Its efficacy might be increased by including data-driven weights for the constituent factors and by developing it at higher resolution levels.
Feofilovs et al. (2024)	Climate Change-Related Disaster Risk Mitigation through Innovative Insurance Mechanism: A System Dynamics Model Application for a Case Study in Latvia.	System Dynamics (SD)	The findings of a case study carried out in a city in Latvia emphasize how crucial it is to use creative insurance mechanisms in conjunction with efficient disaster risk reduction techniques to

Name (year)	Title	Metodhology	Result
			lower total catastrophe expenses. The created model's believability is reinforced by the logical coherence observed throughout the study of the scenario simulation outcomes.
Kyriakopoulos et al. (2022)	Benefits and Synergies in Addressing Climate Change via the Implementation of the Common Agricultural Policy in Greec	Diagnostic analysis	Though specific actions are required to enable the management of the Greek agricultural sector while addressing the risks of climate change, environmental degradation, and excessive use of natural resources, the national strategic framework is in line with the goals and

Name (year)	Title	Metodhology	Result
			priorities of European policies regarding the environment and climate. The results emphasize how crucial it is to make much-needed changes to national strategic planning.
Stricker et al. (2022)	Green Insurance : A Roadmap for Executive Management.	Comprehensive roadmap	In order to achieve green insurance, the roadmap specifies the steps that must be followed and the KPIs that must be monitored in the areas of product development, marketing and sales, risk management and underwriting, operations, and claims management. To support sustainability

Name (year)	Title	Metodhology	Result
			goals and cover the whole range of operations, including claims, it is necessary to examine current goods, risk appetite, and operational procedures.
Hassani et al. (2020)	Big Data and Actuarial Science	Data analytics and data mining	High penetration of insurance policy pricing in nearly every actuarial field, with the exception of cybersecurity risk modeling and pricing, where there is a dearth of data and current data asymmetry. As a result, we found that applying artificial intelligence, specifically machine learning techniqu

Name (year)	Title	Metodhology	Result
			es, could be a potential way to increase the accuracy and results of policy pricing.
Wang et al. (2023)	The Impact of Air Pollution Risk on the Sustainability of Crop Insurance Losses	Generalized additive model (GAM) and extreme gradient boosting	The findings highlight the need for crop insurance managers to integrate air quality considerations into their risk processes to ensure the sustainability of the industry and pricing strategies in the face of evolving environmental challenges.
Rokicki & Ostaszewski (2021)	Actuarial Credibility Approach in Adjusting Initial Cost Estimates of Transport Infrastructure Projects	Regression analysis (OLS) or machine learning (LASSO)	In most situations, actuarial credibility performs better than other forecasting techniques, even if forecasti

Name (year)	Title	Metodhology	Result
			ng accuracy varies depending on the type of project. Therefore, we contend that in order to enhance project planning and prevent cost overruns, actuarial credibility should be viewed as a reasonably easy-to-use instrument with extremely low data requirements that investors and policymakers can readily apply.

As the globe struggles with environmental disturbances and changing socio-economic landscapes, it is becoming more and more important to modernize actuarial practice to address climate change and social challenges. Actuaries, who have historically concentrated on risk management, are in a unique position to be crucial in reducing the effects of and adapting to climate change, especially in industries like infrastructure, insurance, and agriculture. Actuarial techniques must advance beyond conventional risk assessment models in light of the escalation of catastrophic weather occurrences, sea level rise, and unpredictable environmental

trends. In order to effectively analyze climate change risks and inform decision-making, modern actuarial methodologies must integrate data-driven insights from environmental science, climate models, and sustainability measures (Koliokosta, 2023).

Combining cutting-edge data analytics and machine learning methods is a crucial modernization topic. Actuaries may more precisely forecast the financial effects of climate-related catastrophes, such natural disasters, crop failures, and infrastructure damage, by utilizing big data. For example, by adding more detailed data, instruments such as the Actuaries Climate Index (ACI) can be improved in their ability to predict how extreme weather would affect insurance premiums and agricultural production. Actuaries can model the intricate relationships between environmental, social, and economic elements with the use of system dynamics models, as shown in research devoted to catastrophe risk reduction. This enables the development of more effective risk mitigation measures (Zhou & Vilar-Zanon, 2024).

Actuaries also need to think about how their work will influence society as a whole, especially in developing nations and disadvantaged groups that are disproportionately impacted by climate change. Modern actuarial processes may help create insurance products and policies that not only cover against environmental hazards but also promote long-term resilience and equality by incorporating ideas of sustainability and social responsibility. This might entail creating new insurance models, such "green" insurance, which promotes climate adaptation and encourages sustainable behavior (Wynn et al., 2024).

Actuaries are also increasingly required to work with other academic fields, such as environmental scientists, legislators, and business executives, to make sure that their models capture the complexity of social problems and climate change. Working with AI, data science, and other cutting-edge technologies can help actuaries provide more innovative solutions to today's issues. Additionally, actuaries must continue to strengthen their adaptability and forward-thinking skills while focusing on societal needs such as climate resilience and sustainable development. If actuaries can transform uncertainty into

opportunity and highlight the profession's role in building a resilient future, they may continue to be valuable in a world that is changing rapidly. For instance, adding environmental and social governance (ESG) considerations to actuarial models can offer a more comprehensive view of the possibilities and threats posed by climate change. In light of the financial industry's growing focus on sustainability, actuaries need to keep ahead of the curve by adopting cutting-edge techniques and technologies that enable them to evaluate, value, and control the risks related to climate change (Tovar-Ortiz et al., 2024).

Conclusion

In conclusion, actuaries can better offer creative answers to contemporary problems when they collaborate with AI, data science, and other emerging technologies. Actuaries also need to continue becoming forward-thinking and adaptable, concentrating on social demands like sustainable development and climate resilience. Actuaries can continue to provide value in a world that is changing quickly if they can turn uncertainty into opportunity, and emphasize the profession's role in creating a resilient future. Updating actuarial practice to tackle societal concerns and climate change necessitates a multifaceted strategy that combines cutting-edge data analytics, interdisciplinary cooperation, and a strong dedication to sustainability and social responsibility. Actuaries may improve their conventional function in risk management and play a significant part in the global endeavor to solve the issues brought about by climate change and build a more resilient and sustainable future for all by embracing these developments.

Actuaries should make investments in cutting-edge data analytics tools, such as machine learning, artificial intelligence, and big data techniques, to enhance the precision of risk assessments associated with climate change and effectively modernize actuarial practice in response to societal issues and climate change. This involves incorporating socioeconomic, climatic, and environmental data into actuarial models to provide more accurate forecasting and decision-making. Together with insurers, actuarial experts should create policies that take into account the new risks brought on by climate change in

addition to more conventional dangers. Communities and corporations may reduce environmental risks and promote sustainability by creating green insurance, climate adaption programs, and disaster bonds.

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