International Journal of Core Engineering & Management
Volume-6, Issue-07, 2020 ISSN No: 2348-9510

ASSESSING THE RISK: A REVIEW OF CLIMATE CHANGE'S INFLUENCE ON INSURANCE PREMIUMS AND CLAIMS

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Abstract

As the climate changes, homeowners' insurance is being increasingly affected by rising premiums, exploding claims, and underinsurance that is widespread. Higher financial burdens of insurers and policyholders due to the rise in natural disasters like hurricanes, floods, and wildfires in both frequency and intensity. The homeowners' insurance industry is more vulnerable to the growing severity of climate change-related threats, resulting in high levels of underinsurance, huge costs and mounting premiums. The focus of this case study is how climate change affects homeowner's insurance claims. The study uses 62 871 wildfire-related claims data from the California Department of Insurance to show that insurers' pricing strategy is short of systemic. A key finding shows that in 2018, 62.47% of total loss claims were underinsured, with an average amount of coverage deficit of 31.67%, compared to 37.98% underinsured on average in 2019. The increasing frequency of climate-enabled disasters and ongoing errors in rebuilding cost estimates are to blame for these trends, which necessitate the creation of more accurate forecasting tools and modifications to existing policies. Nonetheless, analysis of non-catastrophic losses demonstrates that 76.47% of claims have inadequate coverage. Along with ERC distribution patterns that suggest that many homeowners still face financial vulnerabilities, this also needs to be taken into account. The study's findings emphasize the necessity for insurers to enhance risk assessment techniques, boost their sufficiency, and use flexible tactics to lower their exposure to financial risks associated with climate change.

Keywords— Environment, Global warming, Natural disasters, Climate Change, Insurance Premiums, Insurance Claims.

I. INTRODUCTION

The past few centuries have seen a severe impact on the environment, a delicate balance of natural processes caused by human activities. A continuous increase in global temperatures has been caused by industrialization, deforestation, and the combustion of fossil fuels; these three factors are together known as global warming; this is mainly due to global warming[1]. The increasingly erratic climatic patterns brought on by global warming are causing more frequent severe weather events, including heat waves, storms, and heavy rains. Climate change is when

long-established weather patterns are disrupted, and it is changing the world and reshaping the world in ways that touch on ecosystems, human societies and industries far and wide.
The effects of various industries, including the insurance business, are beginning to feel the strain as a result of the growing awareness of climate change[2]. The insurance industry, which controls people's risk and offers insurance covering losses, has difficulties when climate-related disasters increase in frequency and severity. For that reason, the growing intensity of severe events and the increasing unpredictability of weather patterns have prompted insurers to reassess their risk models. Due to the evolving climate, insurers have had to adapt by adjusting their pricing, policies and limits of coverage to mitigate against the natural disaster risks that continue to grow[3].

The shift in the insurance sector has major implications for homeowners whose properties are increasingly being at risk from climate-induced disasters. Floods, wildfires, hurricanes, and other such events are becoming more common, and as a result, insurers see more claims, higher premiums and tougher coverage conditions[4]. Such an increased frequency of these climate-related events has become a cycle among homeowners who pay higher costs for coverage and insurers who cannot balance profitability with their ability to offer adequate protection. Such changes are no longer only affecting the affordability of homeowners insurance but also the availability of such coverage in high-risk areas[5]. As the climate continues to change, the insurance and homeowners must adapt to the changing realities of a warming planet and the insurance industry – with its function to ameliorate the financial effects of climate-related disasters – has a significant part to play.

A. Motivation and Contribution

Climate 'disasters', including wildfires, have increased financial risk for homeowners because of their more frequent and severe occurrence. But a number of them are underinsured given outdated risk models, few choices for coverage and increasing reconstruction costs. Thus, policyholders are subjected to significant financial shortfalls. This study focuses on understanding the trends of underinsurance in reference to the above challenges and also looks at gaps in coverage with the main objectives of suggesting risk assessment improvements, policy adjustments, and financial resilience in homeowners' insurance. This study makes use of data to analyze how climate change exacerbates underinsurance issues in homeowners' insurance claims through a case study of wildfire losses in California. Key contributions of this paper are:

- The study uses 62,871 wildfire insurance claims to quantify a growing trend of underinsurance and shows how insurers are pricing systemically shortfalls in the valuation of insurance.
- Identifies that Coverage A and ERC policies have inadequacies for both CAT and Non-CAT losses.
- Highlights monetary shortfalls due to inaccurate risk modeling and rising reconstruction costs.
- Advocates for improved risk assessment, regulatory interventions, and policy reforms.

- Provides data-driven strategies to enhance insurance pricing, coverage adequacy, and climate resilience.

B. Justification and Novelty

This study is justified by the growing impact of climate change on homeowners' insurance, leading to widespread underinsurance and financial vulnerability. Unlike previous research, which primarily focuses on broad climate risks, this study provides a detailed empirical analysis using real-world claims data from the California Department of Insurance. Its novelty lies in quantifying valuation shortfalls, identifying systemic coverage gaps, and offering data-driven recommendations to improve risk modeling and policy adequacy.

C. Organization of this paper

The outlier of this paper is as follows: Section II explores climate change's impact on natural disasters and increasing weather-related risks. Section III discusses statistical approaches for assessing insurance risks. Section IV examines predictive modeling for insurance valuation. Section V reviews the literature and research gaps. In the final section, VI, recommendations, conclusions, and future directions of such risk assessment and policy frameworks are offered.

II. CLIMATE CHANGE AND NATURAL DISASTERS: A GROWING RISK FOR HOMEOWNERS

The climate change is on the rise, and natural disasters are going to happen more frequently and more severely, which has become an increasingly bigger concern for homeowners[6]. Floods, hurricanes, wildfires, heatwaves etc. which, are not only causing physical damage to properties in the areas on the spot but are also a financial burden in the long run. In doing so, homeowners have to seek financial compensation for these damages either through government relief programs or insurance policies.

A. Rising Willingness to Pay for Insurance

The result is that homeowners' as the consequences of climate change intensify, so will the willingness of consumers to pay (WTP) for insurance. This is because natural hazards of higher frequency and intensity increase the likelihood of property damage and, therefore, increase the probability of homeowners seeking financial protection[7]. In particular, consumers are likely to demand increased coverage to protect homes and livelihoods from uncertainty and risk associated with the growing number of climate-related events.

B. Insurance Demand and Market Dynamics

Quantitative modeling is important to know how changes in the risk and insurance premium affect the insurance market. Using the demand for insurance under climate change, the market share of insurers is forecasted, and impacts associated with different premium costs are predicted. If the increased expected losses from climate change give rise to increased premiums in line with the changes in household demand for insurance, the changes are not significant.

However, if the insurance is still deemed appropriate, premiums will change to reflect the increased risk, and consumers may still be willing to buy insurance even though the costs are higher.

C. Bounded Rationality and Consumer Behavior

One important aspect to consider in understanding insurance demand is the concept of bounded rationality. Homeowners frequently make irrational choices when buying insurance, particularly when dealing with low-probability but high-impact dangers. This failure to follow expected utility theory is particularly common in scenarios where the potential consequences of natural disasters are extreme but perceived as unlikely, leading homeowners to underestimate the risks. Such behavioral factors need to be considered when assessing and designing insurance products.

III. THE ROLE OF INSURANCE IN CLIMATE CHANGE ADAPTATION AND RISK MANAGEMENT

The potential role of insurance policies in reducing the likelihood of natural disasters and encouraging adaptation to predicted rises in the likelihood of extreme weather occurrences brought on by climate change. In order to cover the substantial costs of natural disaster-related damage to both individual homes and businesses, insurers collect premiums from a huge number of people. Insurance policies share risks in this way by lowering individual loss exposures. Primary insurers can further combine this risk with other types of risk they insure and hedge by purchasing reinsurance coverage from reinsurance companies that disperse risk over wide geographic markets or by using weather derivatives such as catastrophe bonds, options, and futures to hedge risk on capital markets[8]. Because insurance increases financial stability, its risk-spreading effect may benefit risk-averse people. In reality, studies on how flood catastrophes affect people's reported life happiness in 16 European nations show that areas with flood insurance do not experience the lower life satisfaction levels often seen following flood occurrences [9].

A. Insurance and Climate Adaption

The market's inability to support the most vulnerable is not the only reason to incorporate insurance into a climate adaption program, but also the possibility that insurance systems that aid in the recovery of nations and impacted households from extreme weather events may also lessen their effects [10]. Reducing threats to property, assets, livelihoods, and lives is what the climate community refers to as adaptation. Examples of adaptation include strengthening physical systems, such as flood defenses or early warning systems; modifying social systems, such as altering or transferring sources of income; training early warning systems; and addressing fundamental weaknesses, such increasing productivity and allowing savings to act as a buffer against future calamities. These risk-reduction initiatives might be supported by insurance by:

- Providing discounts on premiums and other rewards for lowering hazards;

- Combining the need for risk reduction with insurance support.
- Increasing production such that losses can be decreased over time.

B. The Impact of Climate Change on Insurance Affordability and Availability

In certain areas, insurance coverage has already decreased as a result of catastrophic weather occurrences, and this pattern is likely to persist if losses rise in the future.[11]. Naturally, the effects differ based on the particular situation and might range from very little (slow price hikes) to more substantial. Even though the 1994 Northridge Earthquake had little to do with the weather, it serves as a stark reminder of how shifts in the patterns of natural disasters may have detrimental impacts on customers and raise significant concerns about insurability. All of the aforementioned observations point to an increase in insurability issues, which leads to structural modifications that modify the existing risk-spreading formula.

Almost all of the categories of climate-related losses have looked at are already prepared for or recovered from by governments, and they will be asked to do more. Customers and businesses will have to bear a greater share of the increasing absolute level of losses as either directly or indirectly as taxpayers who foot the bill for government assistance following extreme weather events brought on by climate change. This will be done by deductibles that take place prior to paid losses and expenses that surpass coverage restrictions [basically as "self (re)insurers"). Governments impose comparatively modest loss caps ($250,000 for personal lines and $500,000 for commercial policies), and typically exclude items like short-term living expenditures and business interruptions, as is the case with the current flood program. As long as regulators permit an appropriate mix of rate hikes, the freedom to change conditions and market participation, insurers can be severely shielded from the repercussions.

C. Risk Assessment and Climate Change: A Localized Approach

Policymakers have a problem when people realize how serious the effects of climate change may be and try to adjust: while significant repercussions are anticipated, it is still unclear what those effects will be and how much of them will occur at the regional level[12]. Resolving this issue can be greatly aided by a risk management technique that grounds policy decisions on the probability and seriousness of certain outcomes[13].

Analyzing Through risk assessments, stakeholders can also learn about the anticipated effects of climate change. Using information on natural resources, production practices, and vulnerable people, researchers may predict the potential consequences of specific climate change phenomena, such as temperature increases, rainfall changes, and sea level rise, starting with the findings of the more general risk assessment.

Local decision-makers can benefit from knowing the dangers that exist now and identifying groups that are at risk. Better risk management is also likely to promote economic growth. Policy frameworks for climate change adaptation ought to begin with this type of risk assessment. 39. Sadly, these risk evaluations are rarely carried out in nations with lesser

International Journal of Core Engineering & Management
Volume-6, Issue-07, 2020 ISSN No: 2348-9510

incomes.

IV. A CASE STUDY BASED ON IMPACT OF CLIMATE CHANGE ON HOMEOWNERS INSURANCE CLAIMS

This section examines how climate change exacerbates homeowners' insurance challenges, leading to underinsurance and financial strain. It explores coverage gaps, inaccuracies in risk models, and rising premiums. Using data from the California Department of Insurance, including 62,871 wildfire-related claims obtained through Public Records Act requests, the study highlights valuation shortfalls in insurers' pricing. It underscores the urgent need for improved risk modeling and policy adjustments to ensure adequate protection amid increasing climate-related disasters. Destroyed home frequency based on year is provided in Table I below.

TABLE I. FREQUENCY AND AVERAGE DEPT OF UNDER INSURANCE OF DESTROYED HOMES

Year	nTL claims	nTL underinsured	% underinsured	Average % underinsured
2018	7749	4841	62.47 %	31.67 %
2019	490	191	37.98 %	27.26 %
Total	8239	5032	50.22 %	29.46 %

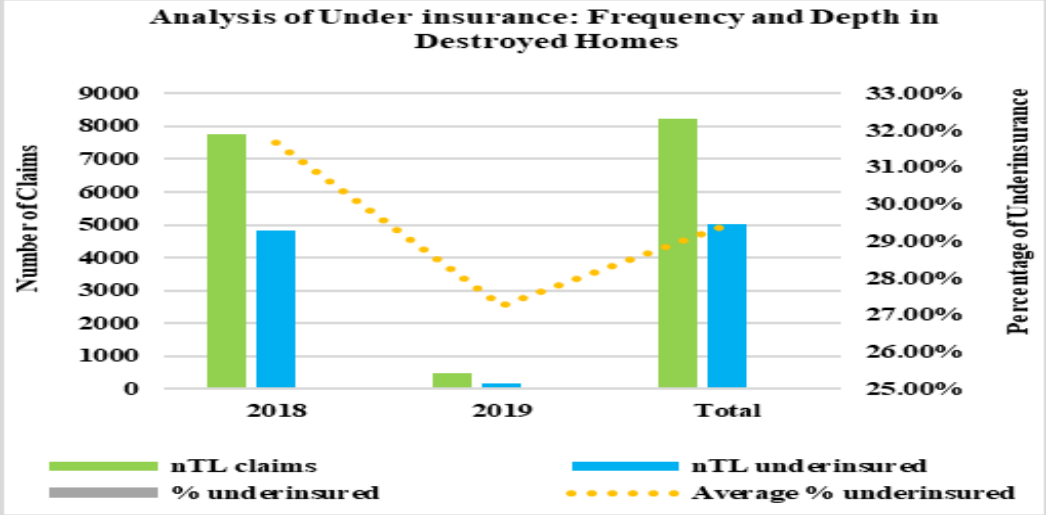

Fig. 1. Bar Graph for Destroyed Homes

Table I and Figure 1 demonstrate how climate change is increasingly affecting trends in homeowners' insurance underinsurance. In 2018, 62.47% of total loss claims were underinsured, averaging 31.67% coverage shortfall, while 2019 saw a decline to 37.98%. Persistently inaccurate reconstruction cost estimates and rising climate-related disasters exacerbate underinsurance, leading to higher premiums, financial risk, and policy inadequacies for homeowners.

International Journal of Core Engineering & Management
Volume-6, Issue-07, 2020 ISSN No: 2348-9510

TABLE II. FREQUENCY AND AVERAGE DEPTH OF INADEQUATE COVERAGE A IN NON-CAT TOTAL LOSSES

Year	nPe, P_G CovA <IL	Freq. Cova<IL	Avg % CovA < IL
2018	415	79.05 %	34.42 %
2019	286	73.90%	36.91 %
Total	701	76.47 %	35.66 %

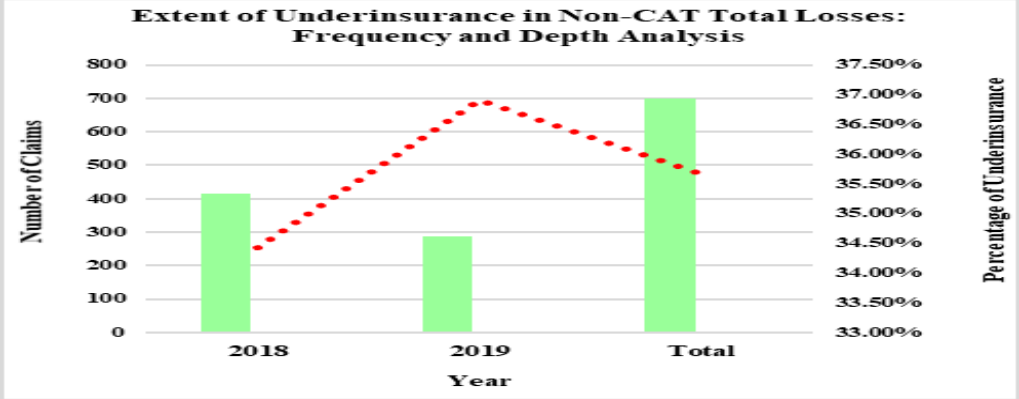

Fig. 2. Bar Graph for Non-CAT losses

Persistent underinsurance in non-catastrophic (Non-CAT) total losses remains a significant issue, with 76.47% of claims having inadequate Coverage A and an average shortfall of 35.66%. Table II and Figure 2 illustrate these trends, showing that while underinsurance frequency declined from 79.05% (2018) to 73.90% (2019), severity increased. These trends indicate systemic valuation gaps, rising reconstruction costs, and insurer miscalculations, emphasizing the need for improved risk modelling and policy adjustments to mitigate financial burdens on homeowners.

TABLE III. DISTRIBUTION OF EXTENDED REPLACEMENT COST (ERC) COVERAGE LEVELS BY YEAR

ERC Coverage Level	Percentage of Policies (%)
50% ERC	~38%
25% ERC	~31%
20% ERC	~24%
No ERC	~7%
Total	100%

International Journal of Core Engineering & Management
Volume-6, Issue-07, 2020 ISSN No: 2348-9510

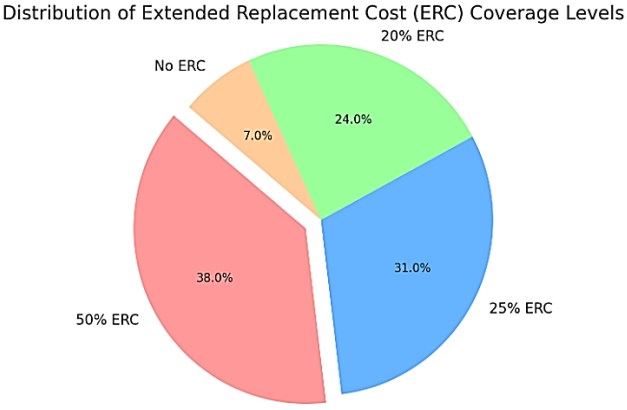

Fig. 3. Pie Chart for ERC Coverage Levels

Table III and Figure 3 illustrate ERC coverage distributions, showing that the majority (38%) holds 50% ERC coverage, followed by 31% (25% ERC), 24% (20% ERC), and 7% with no ERC. The findings emphasize the need for insurers to reassess coverage adequacy amid rising reconstruction costs and climate-induced financial vulnerabilities.

TABLE IV. FREQUENCY AND AVERAGE DEPTH SHORT OF POS RCES PREDICTION TL

Year	nTLs	Freq. POS RCE < TL	Avg. $$ shortfall
2018	7087	97.23 %	$202,364.31
2019	451	76.72 %	$135,601.89
Total	7538	86.97 %	$337,966.20

Table IV analyzes POS RCE prediction shortfalls, highlighting the frequency and average financial deficit in total losses (TLs). In 2018, 97.23% of TLs had an RCE prediction shortfall, averaging $202,364.31, while in 2019, the shortfall frequency was 76.72%, with an average deficit of $135,601.89. Overall, 86.97% of TLs experienced underprediction, totaling a $337,966.20 shortfall, underscoring the need for more accurate risk assessments in homeowners' insurance.

V. LITERATURE REVIEW

In this section, previous work on climate change on home insurance using various methods and techniques. Numerous reviews are:

Némethová et al. (2019) Analyze how global climate change affects this aircraft type's performance, especially the warming and temperature changes, and make inferences about how these elements could affect the effectiveness, affordability, and safety of air traffic flow control. A system study of temperature variations and the operating capabilities of the chosen aircraft type are included in the article's theoretical and practical sections. The study's conclusions and advantages address the contemporary problem of how operational features of both military and

commercial aircraft may be impacted by global climate change. The Knowledge Alliance of Aviation Education also includes this experience. The international expert database of experience in both military and civil aviation is continually being developed[14].

Fidalgo, de São José and Silva (2019) Examine the effects of climate change on Portugal's energy mix throughout the medium to long term (until 2050). Forecasts of installed electricity by type and consumption, as well as climatic scenario simulations, form the basis of the suggested technique. An energy accounting simulation tool receives the combinations of these criteria and uses them to synthesize all the data and produce a description of the system state for each scenario. According to the most optimistic projections, a medium-term, all-renewable electrical system is feasible and consistent with EU goals, provided that investments in renewable energy sources are encouraged in the upcoming years[15].

Valverde and Convertino (2019) Analyse the potential effects on profits of various hypothetical situations involving catastrophic weather disasters, such as a storm on the scale of Katrina combined with a mass terror attack on the scale of 9/11 or a string of storms similar to the ones that hit the US in 2004. At the systemic aggregation levels, the P/C industry has a significant degree of macro-resilience, according to their findings. Furthermore, by taking into account both the pace of recovery and the inverse of the area under the unaffected system profile, they discover that insurer resilience is stronger for bigger damages. They conclude with a summary of their study and a statement that addresses the potential implications of their results for P/C insurers in the future[16].

Lyubchich et al. (2019) that climate change is mostly to blame for the rising insurance risks as it is causing more and more changes and long-lasting effects on every facet of human existence and well-being. This, in turn, necessitates creating novel analytical techniques that go outside the conventional academic limits of statistical, actuarial, and environmental sciences, especially when combined with the difficulties posed by large climate data. With a focus on disaster prevention, they provide cutting-edge insights and cross-disciplinary viewpoints on various statistical and machine-learning methods for evaluating and simulating climate risk in agricultural and house insurance contracts[17].

Miljkovic, Miljkovic and Maurer (2018) Create a fixed effects panel data model that shows how precipitation has a greater influence on property damage than severe temperatures due to climate change. The results of the Dumitrescu-Hurlin panel data causality test showed that the death rates of middle-aged and older individuals were higher when Granger property damages were present. Consequently, property damage can be utilized to enhance the forecasting of future death rates in the United States. Their research has implications for the insurance sector, which is now looking for methods to account for the consequences of warming temperatures. In order to educate the insurance industry on the effects of extreme weather and the risks involved, it is creating the Actuaries Climate Index and the Actuaries Climate Risk Index [18].
Yevdokimov (2017) To track these effects across time, a dynamic computable general

equilibrium model (CGEM) was built. The model's architecture is offered together with a discussion of the fundamental ideas of the planned CGEM. The components of the model are estimated, and an exogenously induced shock is used to test the CGEM that is produced. On the basis of thorough time series analysis, examined are the evolutionary dynamics of sea level, precipitation, and regional temperature. These dynamics will then be applied to the projected CGEM as external productivity shocks. To provide benchmarks for the mitigation strategies related to the RRTN's future development, a few initial cumulative economic effects are assessed in monetary terms[19].

Table V reviews research that uses statistical analysis, machine learning techniques, and simulation models to examine how climate change affects a number of industries, such as aviation, energy, insurance, and economic productivity. Key findings highlight climate change-induced risks, resilience strategies, and the need for adaptive policies in the insurance and energy sectors. Future research should focus on expanding datasets, real-world validation, and sector-specific mitigation strategies.

TABLE V. SUMMARY OF STUDIES ON CLIMATE CHANGE IMPACT ON HOME INSURANCE AND RELATED SECTORS

Study	Focus Area	Methodology	Key Findings	Limitation/Future Work
Némethová et al. (2019)	Climate change's effects on aircraft performance	System evaluation of operational performance and temperature variations	Climate change affects aircraft operational parameters, economy, and safety	Limited to a specific aircraft type; future work could expand to multiple aircraft models
Fidalgo, de São José, and Silva (2019)	Climate change effects on Portugal's energy mix	Climate scenario simulation and energy consumption forecasting	It is possible to achieve a completely renewable electrical grid with sustained investment	Assumes constant investment; future work could analyze policy impacts on renewable energy adoption
Valverde and Convertino (2019)	Profitability impact of extreme weather on insurance	Scenario analysis of large-scale weather events and terrorism	P/C insurers show macro-resilience to extreme events	Focuses on U.S. events; future research could analyze global insurance market resilience
Lyubchich et al. (2019)	Climate risk in agricultural and home insurance	Statistical and machine learning models for Climate Risk Assessment	Emphasizes interdisciplinary approaches to modeling climate risks	Requires more real-world validation; future work could integrate real insurance claim data
Miljkovic, Miljkovic, and Maurer (2018)	Climate change impact on mortality and property damage	Fixed effects panel data model and causality analysis	Property damages due to climate change contribute to increased mortality rates	Focuses on U.S. population; future studies could extend to different demographic regions
Yevdokimov	Climate	General	Regional economic	Requires more detailed

(2017)	change's effects on the economy	equilibrium model that is dynamic and calculable (CGEM)	productivity and mitigation strategies are impacted by climate change	sectoral analysis; future work could integrate industry-specific impacts

VI. CONCLUSION

This study shows the magnitude of climate change on homeowners' insurance, its growing underinsurance problem and financial vulnerability. According to data from California wildfire-related claims, systematic modeling flaws in risk modeling are found, with a consistent underestimating of reconstruction costs leading to significant coverage gaps. This makes it even harder for homeowners to secure adequate coverage in terms of non-catastrophic losses and extended replacement cost coverage trends. According to the findings, inaccurate pricing models, higher reconstruction costs and more frequent climate-related disasters are the main reasons why they are underinsured. The risk mitigation for these risks necessitates better predictive modeling, better policy structures and more strategic interventions to role homeowners into an appropriate level of coverage as the climate challenges intensify.

VII. LIMITATIONS AND FUTURE WORK

The study has limitations because it uses historical insurance claims data from California, which could not fully reflect the range of climate-related hazards and insurance practices that exist in other US areas and other nations. The research examines wildfire insurance losses solely, while other natural disasters causing homeowners' insurance market changes, such as floods and hurricanes, receive limited attention. As now changing climate patterns are not well represented in currently used predictive models for risk assessments, they have a limited accuracy. To boost prediction accuracy, new research needs to work with different types of data and live climate predictions as well as learning-based risk modeling tools. Decisions made by regulators alongside policy frameworks need research attention because they can develop sustainable insurance solutions that adapt to mounting climate change impacts.

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