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Adapting the Insurance Value Chain to Catastrophic Risk: toward Sustainable and Equitable Risk Management

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ABSTRACT

OBJECTIVE

This study aims to explore how insurance companies are restructuring their value chain—both primary and support activities—in response to the growing incidence and severity of catastrophic risks, particularly those driven by climate change. It examines the critical role of the insurance sector not just as a financial intermediary, but as a strategic actor in disaster risk reduction, mitigation, and resilience-building. The paper also investigates the transformative impact of sustainable insurance practices—such as precycling, recycling, and green insurance—on promoting social and environmental equilibrium in the face of increasing natural disasters.

DESIGN METHODOLOGY

The research methodology is qualitative in nature and based on an extensive review of scholarly articles, white papers, and industry reports sourced from reputable databases including JSTOR, ScienceDirect, Wiley Online Library, and Google Scholar. The study integrates theoretical insights from the insurance value chain model and empirical observations on climate-induced catastrophes to identify shifts in insurance operations, strategies, and sustainability approaches.

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FINDINGS

The findings suggest that the insurance industry, although traditionally reactive in its approach, is gradually shifting towards proactive risk management strategies to adapt to the heightened frequency and intensity of weather-related catastrophes. This adaptation is evident across the insurance value chain—from underwriting, claims management, and product development (primary activities) to technology integration, risk modelling, and stakeholder communication (support activities). However, despite advances in digital transformation, critical challenges remain. The lack of access to granular, real-time climate and catastrophe-related data, along with widespread insurance illiteracy—especially in vulnerable and rural regions—continues to hamper the effectiveness and reach of innovative insurance solutions. Furthermore, the industry is beginning to align its investment policies with sustainability benchmarks, emphasizing ESG (Environmental, Social, and Governance) criteria and green asset allocations.

PRACTICAL IMPLICATIONS

The study highlights that climate change poses not only environmental and humanitarian crises but also significant macroeconomic and sectoral risks. India, being one of the most climate-vulnerable countries, stands at a critical intersection of economic development and environmental sustainability. The paper underscores the transformative role insurance can play in bridging this gap by serving as a catalyst for sustainable growth. By offering risk-transfer mechanisms and financial buffers, insurance enables households, businesses, and governments to recover more effectively from climatic shocks. Moreover, sustainable insurance mechanisms—such as precycling (anticipatory risk management), recycling (reintegration of loss learnings into policy frameworks), and green insurance (eco-friendly product design and investment practices)—are identified as essential pathways to ensure long-term resilience and equity in risk sharing.

ORIGINALITY

To the best of our knowledge, this study provides a novel perspective by synthesizing the concepts of catastrophic risk, sustainability, and the insurance value chain in the context of

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climate change adaptation. It contributes to the limited but growing body of literature that examines the intersection of environmental sustainability and insurance industry transformation, particularly in developing economies like India.

Keywords:
Insurance; Sustainability; Value Chain; Catastrophic Risk; Green Insurance; Precycling; Climate Change; Risk Management.

INTRODUCTION

The Indian insurance industry is the 10th largest in the world. Total insurance premiums in India increased by 13.5 % in 2021, and the global average was 9%. (Invest India report). Given the immensity of its investment in the total GDP of the economy, it is perceived as a stabilizer during a crisis. According to IRDAI, India's share in the global insurance market is 2.73%. In 2022, the insurance industry's value addition to GDP was 2.6%. (Insurance Information Institute). According to the EM-DAT international disaster database, the following data are found regarding damage cost due to natural disasters in India were US$ 2.92 billion during the 1970s. The extent of damage costs increased in the subsequent decades from US$ 5.92 billion during the 1980s to US$ 18.41 billion and US$ 23.74 billion during the 1990s and 2000s, respectively. Further, Padmanabhan (2012) reports that the total economic damages due to extreme events were US$ 48.06 billion during the period 1980-2010 – this corresponds to an average of US$ 1.55 billion per annum during the same period, with the direct losses touching about 2% of India's GDP. The data mentioned above shows the growing position of the Indian insurance industry and its major contribution to economic growth. The data also talks about the economic loss caused due to natural disasters. The damage caused by to disaster can be covered by the appropriate and timely action of insurers. The paper tries to identify the role of insurance in maintaining sustainability by taking the environment, social, and governance factors (ESG) approach in its value chain. ESG has 17 valuable goals established by united nation in 2015 which is seen through the lens of sustainability like No poverty, Zero Hunger, Good Health, Quality Education, Gender Equality, Clean Water and Sanitation, Affordable and Clean Energy,

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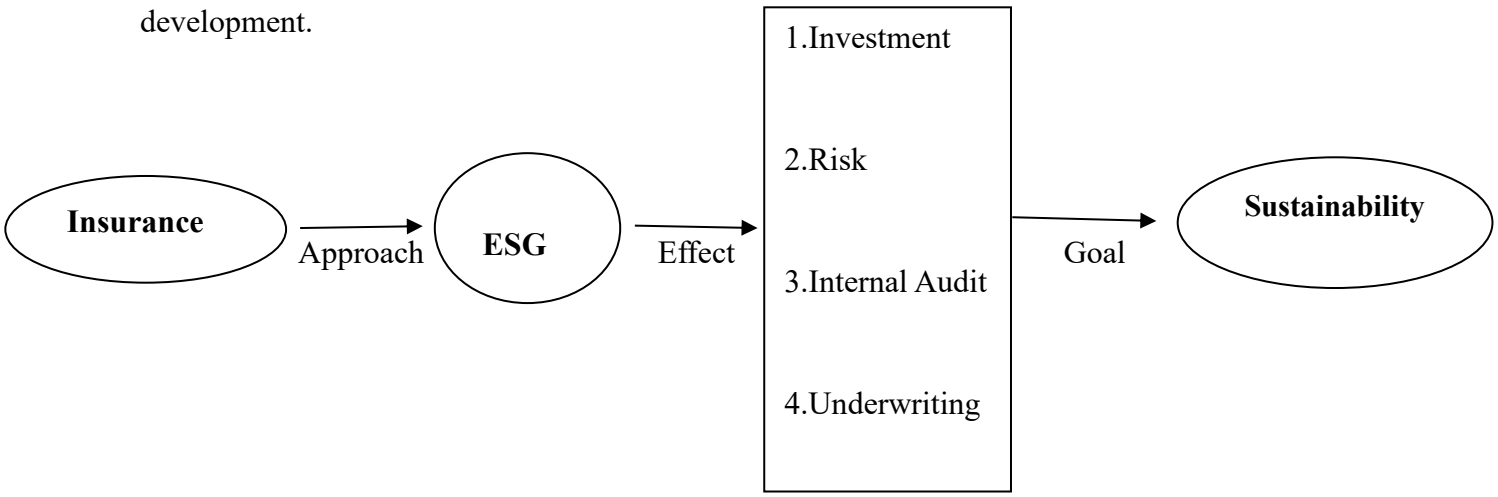
Decent Work and Economic Growth, Industry Innovation and Infrastructure, Reduced Inequalities, Sustainable Cities and Communities, Responsible Consumption and Production, Climate Action, Life Below Water, Life on Land, Peace Justice and Strong Institution, Partnership for Goal. The insurance industry is working towards the following goals, i.e, No Poverty, Good Health, Affordable and Clean Energy, Responsible Consumption and Production, and Life on Land to be achieved. Altogether, it will help in mitigating climatic risk, increasing profitability, more stability, achieving resilience, and maintaining stakeholder expectations.

Due to the turbulent movement of the economy and drastic changes in climatic conditions, the insurance industry is more exposed to catastrophic risk. Investment, Risk management, Internal Audit, and Underwriting activities are directly affected. Industry is identifying and redesigning the specific segment of the value chain, considering ESG as a factor for sustainable development.



1.1 Concept of Sustainability

The existence of sustainability is almost as old and everlasting as the dismal science. In 1798, Malthus was concerned about how Britain would manage to rise in population from a finite amount of land. The International Union for Conservation of Nature and Natural Resources had internationally established the concept of sustainability and sustainable development in the World Conservation Strategy (IUCN) in 1980. This concept was more widely recognized through the Brundtland Commission's 1987 report. Commission defined Sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs ".

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Concerning Sustainability launched a new agenda for development and environmental economies (Pezzey Toman 2002). The idea of CSR revamp by the concept that firm productivity is a product of productive intangibles. The mediating role of productivity is discovered between corporate social performance and financial performance **(Hasan, Kobeissi, Haizhiwang, 2018)**. Financial conglomerates are better performers than individual insurers. Social and Ethical aspects of CSR are better integrated in the business activities of insurers than the environmental aspect **(Scholtens B 2011).** The Creation of the United Nations Environment Programme Financial Institution (UNEPFI)Initiative in 1992 gave a platform for discussion on Sustainable Development Goals (SDGs) in financial services.

The year 2010 marks the year of the green economy, with the capital market and finance playing a major role in the "Green New Deal". The UNEPFI Insurance Working Group (IWG), an academic group, started a survey on understanding and integration of ESG factors in insurance underwriting and product development [3]. UNEPFI Principal for Sustainable Insurance (PSI) was launched at the UN Conference 2012. This initiative is a collaboration between the UN and the Insurance industry. Sustainable insurance is a strategic approach in which primary and secondary activities of the value chain are designed and performed by identifying, assessing, and monitoring risks associated with ESG factors. There are many articles on the application of this standard in the regular operational practice of the insurance industry. **Scordis et al. (2014)** are one of the first to put the PSI in the (general) literature on sustainability and value maximization.

As the financial world is changing rapidly and experiencing roller coaster movement: strategic alliances, on-demand products, demand-based delivery channel, rise of catastrophic risk, AI influence, big data base, technology intervention, etc. This situation leads to a focus on the value chain model of the insurer. The factors that will give direction to a working model of the insurance company in today's economy will be customer, technology, and environment. "A sound national insurance and reinsurance market is an essential characteristic of economic growth" **(UNCTAD,1964)**. Due to deregulation of the financial market, Insurance has a major role as a shock absorber, risk manager, and long-term investor for maintaining a sustainable and inclusive economy.

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1.1 Impact of climate change on the insurance sector

i. Insured property loss will increase after an extreme weather occurrence**.**

ii. Climate change will affect the investment decision, specifically the long-term asset management.

iii. Today's operation of the insurance sector will become more costly. After clearing up the claim, the reserve will be affected.

iv. Underwriting will be affected.

v. As sustainability is affecting the political environment

Challenges for sustainable insurance

Climate change, continuous decrease of renewable resources, a big gap between the above and below poverty line, and technological risks are some of the biggest sustainability challenges faced by the insurance industry.

1.2 Insurance and Its Value Chain Model

External demand and internal potential are giving birth to a new insurance structure which works on preventive measures using back casting, in which planning is attached to a goal, not with current situation.

Value chain is a systematic and fundamental approach to link and analyze the activities that create value addition and competitive advantage in this turbulent economy. Capon (2008) A value chain is "a string of units working together to satisfy market demands." The value chain aims to add more to the bottom line of the company and reduce costs and achieve the managerial goal of the company. The value chain is flexible enough to adjust to changes in the service industry. Value chain model when ESG factors are proxied for value addition and attending to sustainability.

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Redesign of the Value Chain Model from product supplier to service provider

Primary Activities	**Old**	**Action performed**	**New Reality**
Product and Service Development	Restricted product, inadequate consumer service.	Privatization Globalization Digitalization	Diversity of products: Usage-based insurance, i.e., Travel.
Marketing	Products were designed and marketed according to the set rules of the state and the advisory body	Focus on customer retention and building trust by brand management, increasing size through strategic collaboration. Focus on financial literacy	Product positioning and pricing according to demographic, psychographic, and geographical segments. Engaged the customer by using their sentiments.
Distribution and Sales	Rural areas were neglected, focusing only on urban and semi-urban areas. Agents were considered the most trusted people for selling insurance products.	A balance between direct selling, digital selling, agent selling, and through banks is proving to be balanced	Digital platforms for selling and information increased in number in urban and semi-urban urban compared to rural areas. Agents are more in rural areas for the sake of trust
Underwriting	As a policy, we were a regulation-based model product of the least competitive and stable environment.	Data-driven underwriting with the help of technologies Internet of Things. Insurance activities	Premium prices increased. Risk assessment is becoming a challenging task. More options to switch. The

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	Their risk assessment was easy. Accordingly, premium pricing was low	are interconnected with the financial system, so systematic risk plays an important role in risk assessment. Climate is a very vulnerable sustainability Risk, and catastrophic risk is also considered.	performance of the companies is judged based on ESG factors.
Claim Management	Many pending cases for claim settlement, increased operational cost of insurance companies, and Dissatisfied customers	Automation of the claim management process. Sustainable claim	Easy payment of clean claims, Rapid judicial working on disputed claims. The negative impact of the claim on the climate is reduced. The claim reporting process improves a Sustainable claim is both economical for an insurer and customer regarding property.
Investment Management	Investment is managed according to the direction given by the IRDA. The aim was to protect the capital. Maximum investment in govt	Macroeconomic factor influence: increased inflation rate, higher interest rate, Damage loss due to sudden climate change, implementation of	The aim is to generate profit along with the protection of the capital amount. Through the SDG approach, investment is made in green bonds, green infrastructure, and green

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	securities or companies has a trend of dividend payment from long-term	Sustainable investment	assets for the sustainable growth of the company and shareholders

Value Chain: Supporting Activity

Risk management	Old	Action performed	New reality
	Assessment of risk was easy and manageable. The premium pricing was easy to calculate. More cushion capital was not much required	Risk occurring due to sudden climatic change gives rise to catastrophic risk. ESG factor for risk management	To cover catastrophic risk, alter its coverage condition, pricing, underwriting strategies, or method of capital management. The insurance company can increase its reserve or do more reinsurance. Funds available after a disaster help in the resilience of the society

Social inequality has having direct impact on the stability and resilience of the economy. Social insurance, such as Employee Provident Fund, Gratuity, and Inequality, gives protection against various risks like loss of income due to disability or sickness. If income gets minimized, it directly affects the potential growth of the economy. Microinsurance is designed to give protection to the rural section of society. Lee et al (2017) the researcher find that life insurance plays a role in mitigating social inequality, and non-life insurance plays a prominent role in promoting economic growth.

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Problem Statement

The contribution of insurance is significant to the total wealth of the country. The supportive and risk management activity for the transition of society towards sustainability attracts the attention of various people and the government. As incremental improvement is witnessed by the insurance industry till 2000, under which problems were managed according to their impact. Problems were common in nature, identifiable, and concentrated in specific geographical areas. There was no seismic effect. After globalization, digitalization, and drastic changes in the environment, the problems are at a varied level and interconnected. Multiplier effect can be seen in different sectors of the economy due to the claim payment **(Bouakez et al.2022).** This study will help to get valuable information about the role of specific variable factors that directly influence the value chain of the insurance industry. These factors should be considered and controlled on a priority basis for achieving sustainability.

Aim of the Paper

The paper aims to study the adaptation of value chain models of insurance companies with the rise of catastrophic risk due to climate change. How insurance companies are helpful in reducing the aftereffects of a natural disaster. The role of an insurance company in maintaining social resilience and growing to achieve sustainability. For this purpose, articles had been collected from various databases. EBSCO, Google Scholar, Emerald.

Research Contribution

The paper highlights the various areas that need specific attention from insurers, insureds, investors, and stakeholders. It talks about customer-centric value chain models, which will help with more insurance penetration. Technology absorption, which helped in giving symmetric information. The pace with which the insurance industry is coping with climatic challenges and helping in maintaining the growth of the economy.

Paper Structure

The paper is divided into three sections:

- Introduction, which gives a background for the research

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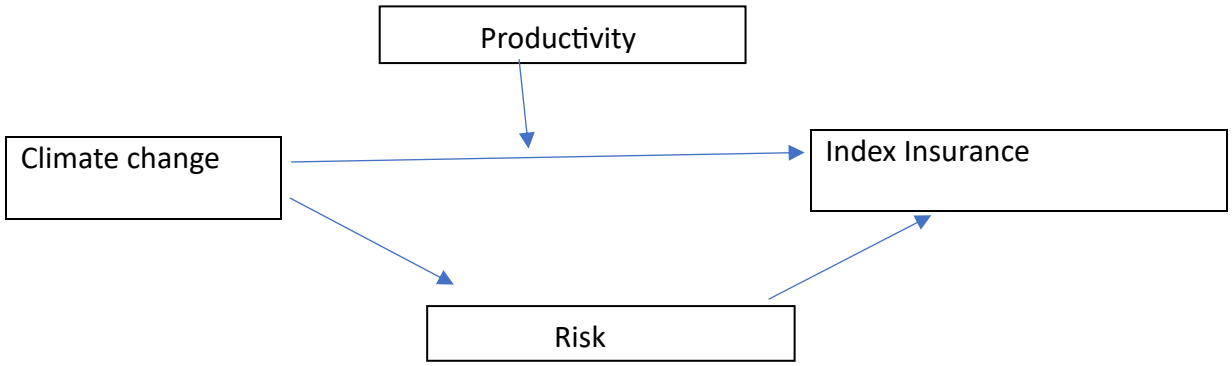
- Literature Review and Research Methodology
- Conclusion of the research

Conceptual Framework



Climate change is an independent variable having a direct impact on the demand for Index insurance. (Index insurance is acknowledged as an adaptive strategic instrument to safeguard against the risk of reduced production due to climate change.) Demand for index insurance decreases when there is an extreme effect of climate change compared to a scenario of no climate change. When farmers face uncertain distribution of loss, they are not able to understand the benefit of insurance, and learning remains stuck to prior beliefs **(Partridge & Wagner,2016; Daron Stainforth, 2016)**. Productivity acts as a moderating factor on the link between environmental performance and climatic performance (Ramanathan, Ramakrishnan, 2016). Productivity is significantly affected by climate change, and it shows lots of variations depending on the operational efficiency of insurers. Different types of risk are growing and emerging due to climate change, which significantly affects the pricing of premiums and product design of index insurance (Pankaj Singh 2022). Catastrophic risk increases the cost of the premium. The benefits of Index insurance are highly influenced by the climate change phenomenon and environmental disasters like drought and flood, etc.

Literature Review

Literature Review consists of a structured and standardized identification process. Keywords used are “insurance” and “economy”, “sustainable insurance “and “value chain”, “insurance”

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and "sustainability", "insurance" and "risk", "ESG" and "insurance", "sustainability" and "growth" factors 30 papers are selected from 50 identified papers. Databases searched are EBSCOhost, Google Scholar.

Papers identified talked about the role of insurance in a growing economy and maintaining its sustainability. Challenges and opportunities faced by the insurance industry due to climate change have been overcome. Optimizing the value chain for implementing ESG factors in its management and operational activities.

The insurance sector has been increasingly recognized for its multifaceted role in driving sustainable development, promoting economic growth, mitigating climate risk, and adapting to technological and regulatory transformations. James Greyson (2006) introduced the concept of *precycling insurance*, a market-led decision-making tool that promotes sustainability before risks arise, aligning well with China's proactive circular economy legislation. A.F. Dlugolecki (2000) addressed the initially slow response of the insurance industry towards climate change but argued that this would change as the sector began to realize the opportunities and threats embedded in environmental risks. This is further emphasized by Lukas Stricker (2022), who analyzed the emergence of *green insurance* in the property and casualty domain as a response to sustainable insurance principles, drawing a roadmap along the value chain to make insurers early movers in climate resilience. At the strategic level, Anton van Rossum (2002) questioned whether insurers should operate as specialists or conglomerates in the changing economic environment and highlighted the importance of optimizing the value chain by identifying high-value-creating segments. Parallelly, Martin Eling and Davide Nuessle (2022) explored how Artificial Intelligence could revolutionize the insurance business model by enhancing predictive accuracy, minimizing asymmetric information, and transitioning from loss compensation to loss prevention—ultimately making operations more cost-efficient and risk-aware. The integration of AI was also studied by Martin Eling and Martin Lehmann (2018), who identified customer experience, product innovation, and inter-sector competition as key transformation zones in the insurance value chain. Focusing on sustainability, several studies explored the role of Environmental, Social, and Governance (ESG) factors. Laura Chiaramonte and Alberto Dreassi (2020) found that ESG-driven sustainability enhances the financial

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stability of American life insurers, with environmental and social factors playing more influential roles than governance. Similarly, Flavio G. Nogueira and Andre F.P. Lucena (2017) presented an integrative ESG model, demonstrating a positive correlation between company size and ESG awareness in underwriting and risk management. The need for robust ESG implementation is echoed by Inna Khovrak (2020), who underscored the importance of improving ESG reporting and disclosure practices, while Silvia Bressan (2023) confirmed that insurers with strong ESG scores tend to have high operational leverage and deliver excess returns, thus creating long-term value for stakeholders. In the Indian context, G. Parvathi (2013) and Debabrata Jana (2020) explored how the liberalization of the insurance sector post-1991 contributed to economic growth. Their work revealed that indicators such as real premium growth rate, total investment, and claim settlement play a significant role in linking insurance to inclusive national development. Complementing this, Rahul Kanojia (2014) examined how sustainability in the Indian insurance sector faces several challenges, including regulatory compliance and strategic alignment. The contribution of insurance to economic development was also strongly emphasized by Patrick M. Liedtke (2007) and Gulzira Serikova and Yerkenazym Orynbassarova (2019), who underlined the sector's role in supporting income stability, savings, and investment as economies become more integrated. On the risk management front, Nadine Gatzert and Philipp Reichel (2020) explored the balance sheet implications of sustainable insurance, noting that opportunities in underwriting and investments are often hampered by data limitations and a lack of internal expertise. Nadine Gatzert (2020) further elaborated on the European insurance market, suggesting that while climate change presents an opportunity, transparency and access to reliable sustainability data remain key barriers. Ruslana Pikus and Natliia Prykaziuk (2018) investigated sustainability in the Ukrainian insurance sector, which is challenged by economic instability and shifting regulations. They identified a multi-layered risk management approach involving the qualitative and quantitative assessment of insurance, market, operational, and strategic risks to protect insurer solvency. From a regulatory and governance standpoint, Asier Garayeta and J. Inaki De la Pena (2022) examined the evolving solvency frameworks across global markets, concluding that the sustainability of these systems depends on a country's regulatory congruence. Meanwhile, Bert Scholtens (2011) revealed that although insurers have integrated

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the social and ethical components of Corporate Social Responsibility (CSR), environmental factors still lag in implementation. In Taiwan, Chao-Chung Ho and Chih Huang (2018) emphasized that CSR practices must be driven by managerial commitment and legal compliance, particularly in a sustainability-focused insurance framework. Furthermore, studies by Marina Brogi and Antonella Cappiello (2022) and Karolina Pulawska and Wojciech Strzelczyk (2023) found that insurers with high profitability, solvency, and diversity in operations show higher ESG awareness and perform better in sustainable investments. In contrast, the systematic literature review by Laura L. Aburto Barrera and Joel Wagner (2022) revealed that while risk management, underwriting, and investment have received considerable research attention, critical areas such as claim management and sales remain underexplored in the context of ESG. Finally, studies like those by Mangulu Charan Dash (2018) and Seema Rawat and Aakankshu Rawat (2021) shed light on behavioral factors influencing insurance decisions, such as risk-bearing capacity, claim-filing motivations, and investment preferences in high-inflation environments. Moreover, Sussan Holliday and Inna Remizova (2021) underlined the insurance sector's potential in supporting the United Nations Sustainable Development Goals (SDGs) by facilitating risk transfer and enhancing economic and environmental resilience. The Intergovernmental Panel on Climate Change (IPCC), in its Sixth Assessment Report (2022), emphasized that agriculture had become increasingly vulnerable to climate-induced events such as droughts, floods, and extreme temperatures. The report underlined the importance of risk transfer mechanisms, particularly crop insurance, in mitigating the socio-economic impacts on farmers, especially in South Asia. According to the Insurance Regulatory and Development Authority of India (IRDAI) Annual Report (2023), significant progress had been made under the Pradhan Mantri Fasal Bima Yojana (PMFBY), including the adoption of technology for faster claim settlements and enhanced involvement of private insurers. However, challenges such as low insurance penetration and a persistent trust deficit among farmers continued to hinder the program's effectiveness. The report recommended further integration of satellite imagery and artificial intelligence for damage assessment to improve credibility and efficiency. Mahul and Stutley (2021) noted the growing relevance of parametric and index-based insurance solutions in economies vulnerable to climate change. Their study advocated for the use of climate data analytics to design sustainable

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and resilient agricultural insurance products. Das and Sethi (2021) drew attention to several structural issues within India's crop insurance framework, including basis risk, delayed claim settlements, and ineffective grievance redressal mechanisms. They proposed a climate-smart insurance model aligned with the Sustainable Development Goals (SDGs), highlighting the need for public-private partnerships and the incorporation of agro-climatic zoning in risk evaluation. A global report by the FAO and OECD (2020), in collaboration with the Swiss Re Institute, showed that agriculture-related losses attributed to climate change had doubled over the past decade. The report emphasized the potential of digital technologies, blockchain solutions, and weather-indexed policies in enhancing the effectiveness and accessibility of agricultural insurance. Chatterjee and Singh (2023) conducted a state-level analysis of PMFBY's implementation and recommended the development of localized risk assessment models, increased stakeholder engagement, and the use of climate resilience indicators to better assess insurance outcomes. UNDP India (2022) documented pilot initiatives in Maharashtra and Odisha, demonstrating that bundled insurance products—combined with advisory services and climate-resilient technologies—had strengthened the capacity of marginal farmers to withstand climate-related shocks and recover more effectively. Narayanan (2021) provided a nuanced evaluation of the role of crop insurance in addressing farmer distress and suicides. The findings suggested that while insurance offered partial protection, it needed to be integrated within a broader risk management framework that included credit access, agricultural extension services, and improved irrigation infrastructure.

CONCLUSION

Climate change, such as an increase in sea level, shift in weather patterns, is forecasted to increase the occurrence and intensity of extreme weather aftereffects in India. It will create a big threat and challenge for the economy. Those who can identify the key trend of climate change can envision the definite opportunities. Based on the level of the need of the country and the risk to be insured against are agriculture, flood, earthquake, property, crops, and natural disaster. Insurer investment management focus will go for renewable sources of energy, green market, green infrastructure, etc. These areas will create new opportunities for underwriting. Natural hazards increase the loss potential of the insurer. They are trying to act proactively and

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take prior initiatives. The insurance industry is trying to move from taking incremental steps to preventive steps. Zero waste, Sustainability, and stable economic growth can only be achieved by a preventive approach. Insurance plays a very eminent role in the economic development of the country by creating direct and indirect employment opportunities.

Due to increased literacy about sustainability awareness, levels of consumer, insurer, investor, and stakeholders are growing. They understand the positive impact of insurance on the adverse effects of climate change. Insurance companies are striving to achieve the goal of sustainability by implementing ESG factors for every activity of their value chain. ESG is the three pillars on which the insurance industry is trying to implement its brand value and trust in the eyes of customers, investors, and stakeholders. Although it is an ambitious approach in today's scene, it will be a prime necessity for the survival of future generations. The growth and stability of an insurance company has a positive relationship with sustainability. In the conceptual framework, productivity is identified as a moderating variable, and risk is identified as a mediating variable between climate change, an independent variable, and the demand for index insurance dependent variable. Although progressively people are becoming aware of the role of insurance in mitigating risk, there is a gap between the associated risk and the product offered. A few key barriers have been identified in these aspects, like illiteracy, asymmetric communication, hindrance of data, standardization of data, etc. Following the sustainability path is a real challenge at present for the insurance sector. A limitation of our study is research related to the database used, considering the topic.

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