



Examining Insurance Mechanisms for Enhancing the Resilience of Iran's Water Resources to Climate Change

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ABSTRACT

Background and Objectives: Iran faces an unprecedented water crisis, fundamentally threatening national security, economic stability, and social well-being. This emergency stems from a dangerous convergence of climatic changes, unsustainable consumption, and institutional challenges. Critical issues include catastrophic groundwater depletion, where extraction rates exceed natural replenishment by factors of 3-4 in vital basins, and the degradation of ancient qanat systems. With rising demand across all sectors and climate change intensifying droughts and floods, innovative financial solutions are essential. Insurance, as a risk transfer mechanism, offers transformative potential beyond conventional compensation, acting as both a financial safety net and a proactive instrument for behavioral change. This research aims to develop a context-specific insurance model for Iran with three primary objectives: designing specialized insurance for protecting and revitalizing qanat systems; creating incentive-based products to promote efficient water consumption in industrial and household sectors; and establishing frameworks for insuring critical water infrastructure against climate-related damages and failures.

Methodology: This research employed a mixed-methods approach through a three-phase framework. The initial phase conducted a systematic global review of existing water-related insurance schemes. The second phase involved a comprehensive diagnostic assessment of Iran's water risk landscape, incorporating climate scenario modeling, infrastructure vulnerability analyses, and evaluation of the domestic insurance industry's capabilities, including case studies of endangered qanat systems. The third phase synthesized these findings to develop evidence-based policy recommendations, validated through extensive stakeholder interviews with over 20 experts.

Findings: The research reveals critical findings. First, insurance mechanisms can effectively address multiple crisis dimensions: Parametric drought insurance for agriculture can provide timely compensation; infrastructure insurance ensures rapid recovery from damages; and "qanat conservation insurance" can link financial benefits to sustainable maintenance practices. Second, substantial market potential exists, with water-related insurance potentially expanding to cover 15-20% of Iran's insurance market. Third, insurance products can create powerful economic incentives for conservation, as international examples show 20-30% usage reductions for better terms. Significant implementation barriers include data limitations, technical capacity constraints, regulatory challenges, and cultural barriers to adoption.

Conclusion: Implementing a specialized water insurance framework in Iran is a crucial strategic advancement toward water security and climate resilience. The proposed model strengthens adaptive capacity by protecting infrastructure, incentivizing sustainable use, and preserving qanats. Success requires strong governmental support, investment in data infrastructure, and effective public-private partnerships. Recommendations include establishing a "Qanat Conservation Insurance Program," developing parametric agricultural insurance pilots, and creating a "Conditional Government Guarantee Fund." The model offers a practical pathway for integrating insurance into Iran's national water management strategy, contributing substantially to long-term sustainability and economic stability.

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Introduction

Water scarcity and climate change pose existential threats to Iran's water, food, and economic security, pushing the nation toward an unprecedented crisis (Ahmadi, Nazari, & Zare, 2021). The country's arid geography, combined with severely declining precipitation rates, continuously depleting groundwater reserves, rising temperatures, and erratic rainfall patterns, has placed immense and unsustainable pressure on its limited water resources (World Meteorological Organization, 2024). These dire conditions not only threaten agriculture the largest consumer of water, accounting for approximately 90% of total usage—but also jeopardize industrial productivity, the integrity of urban water supply networks, and, ultimately, social stability and rural livelihoods. In this critical context, the implementation of integrated risk management and robust climate adaptation strategies is no longer optional but a national imperative. Among the various financial risk management instruments available, insurance holds a distinctive and powerful position as a proven mechanism for transferring and distributing financial risks (Surminski, 2017). By providing timely compensation for a portion of the losses caused by natural disasters and unforeseen climate events, insurance can significantly accelerate recovery processes and reduce the economic burden on households, businesses, and governmental budgets (Clarke & Dercon, 2020). At the international level, innovative insurance products and schemes are increasingly regarded as integral components of holistic climate change adaptation strategies (Global Water Partnership, 2020). For instance, the long-standing U.S. National Flood Insurance Program has demonstrated effectiveness in managing flood-related damages and facilitating the reconstruction of critical urban infrastructure (Kousky, Treuer, & Mach, 2024). Similarly, in many European countries, specialized insurance schemes designed for protecting critical water infrastructure and supporting water-dependent industries have

been successfully implemented with the clear aim of enhancing overall economic and social resilience (Hudson & Botzen, 2023)

A substantial body of international research has demonstrated that the functionality of insurance extends far beyond mere financial compensation after a disaster strikes. As a sophisticated financial institution, it can serve as a potent driver for promoting sustainable water resource management through carefully designed risk-based pricing mechanisms (Botzen & van den Bergh, 2020). For example, when the insurance premium for an industrial facility is calculated based on its specific water consumption patterns, the efficiency of its water systems, and the verifiable risk-reduction measures it has undertaken, the company gains a direct economic incentive to invest in water-saving technologies and adopt more sustainable operational practices (Hudson & Botzen, 2023). This powerful alignment between the economic objectives of insurers and the broader environmental goals of society ultimately enhances the resilience of the entire socio-ecological system against the adverse impacts of climate change. Nevertheless, despite this clear potential and pressing need, the Iranian insurance industry has, to date, failed to take substantial and effective steps toward addressing water- and climate-related risks in a systematic manner.

The conceptual framework for addressing this gap through specialized water insurance mechanisms is presented in Table 1

Table 1. Conceptual framework for integrating water insurance into Iran's water and climate risk management strategy

Level	Key Components	Description
1. Driving Pressures	• Climate Change Impacts • Unsustainable Water Management	Fundamental forces creating Iran's water crisis
2. Key Water Risks	• Severe Droughts • Destructive Floods • Qanat System Collapse • Groundwater Depletion	Specific hydrological challenges facing Iran
3. Insurance Framework	• Qanat Conservation Insurance • Parametric Agricultural Insurance • Incentive-Based Industrial Insurance	Proposed specialized insurance mechanisms
4. Ultimate Goals	• Water Security • Socio-Economic Resilience • Sustainable Water Governance	Long-term strategic objectives

Meanwhile, the water crisis has deeply permeated all economic and social spheres of the country, escalating in severity each year. Successful global experiences clearly highlight the considerable potential of insurance as a complementary pillar within national water management strategies. Surminski and Thieken (2021) have empirically shown that insurance, beyond its traditional role of compensating losses, can directly contribute to proactive risk reduction and long-term resilience-building, thereby positioning it as a key element in modern climate risk governance frameworks. Building on this potential, Figure 1 presents a conceptual framework for

adapting these international experiences to Iran's specific water challenges through specialized insurance mechanisms.

Within the specific Iranian context, although relatively few studies have directly and comprehensively examined the role of insurance in water management, related research has successfully identified the fundamental challenges facing the insurance industry in providing coverage for natural disasters (Ghafory-Ashtiany & Motamed, 2024). Concurrently, these studies confirm the existence of significant and untapped opportunities for developing innovative insurance products in the domain of environmental risk management and climate adaptation within Iran (Ghafory-Ashtiany, 2025). Scholars argue that insurance can serve as a valuable complement to governmental policies in managing complex water crises and can substantially contribute to strengthening the country's economic and social resilience against hydrological shocks. Against this pressing backdrop, the central research question guiding this study is: How can the latent and underutilized capacities of Iran's insurance industry be effectively harnessed and strategically mobilized to achieve the critical national goals of optimal water resource management and successful adaptation to climate change? This pivotal question forms the intellectual core of the present article, which seeks to propose practical, evidence-based pathways for developing and implementing specialized insurance products in the water and climate domain. This will be achieved by critically examining and adapting relevant international experiences while conducting an in-depth analysis of Iran's unique local conditions, constraints, and opportunities, with particular emphasis on creating viable models for qanat rehabilitation insurance and consumption-based incentive schemes.

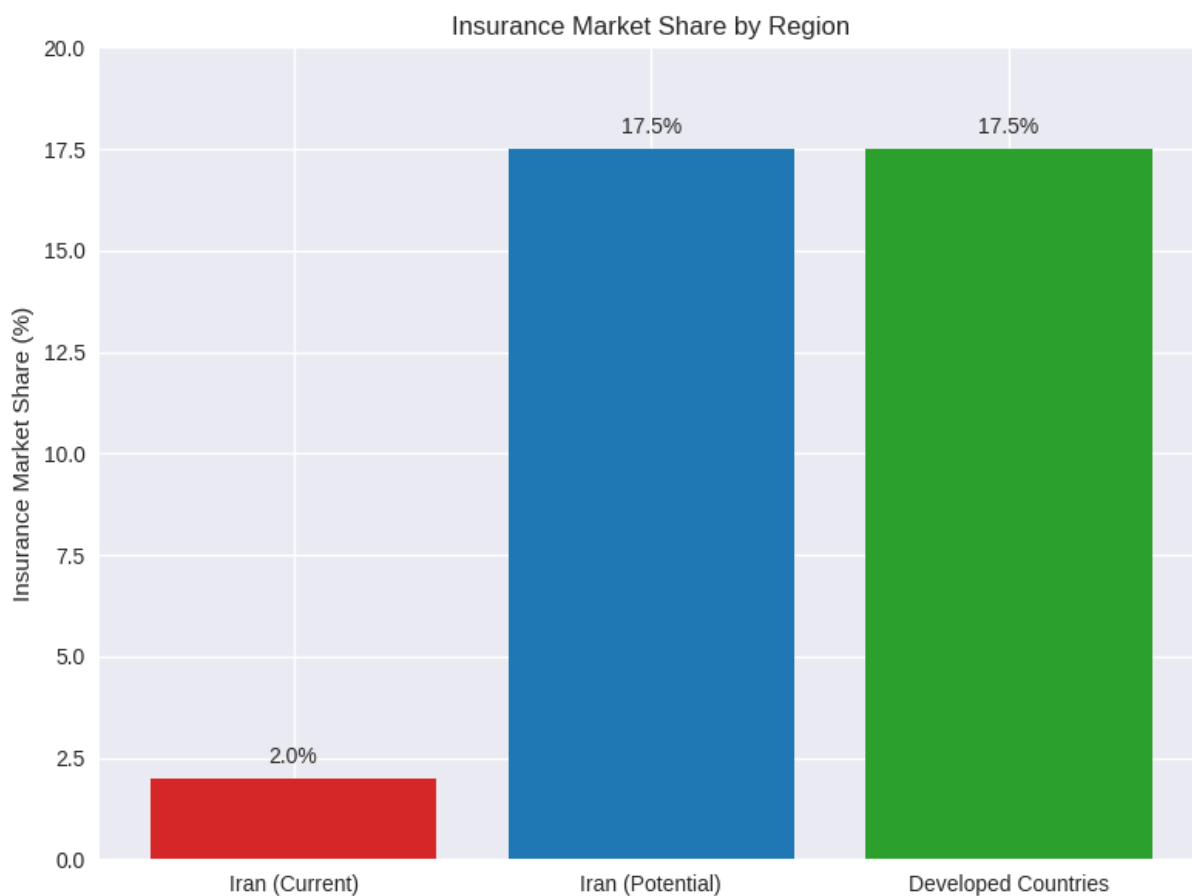


Figure 1. Conceptual Framework for Integrating Water Insurance into Iran's Climate Adaptation Strategy

As illustrated in Figure 1, the framework translates global insurance principles into actionable solutions for Iran by addressing the chain of drivers, risks, and solutions specific to the Iranian context, ultimately leading to enhanced water security and climate resilience

Theoretical Foundations of the Study:

Insurance is fundamentally recognized as one of the most powerful financial instruments within the established literature of economics and risk management, offering a structured approach to mitigating uncertainty (Surminski, 2017): Its functional scope extends far beyond a simple compensatory mechanism. By creating an integrated financial safety net, insurance systematically reduces uncertainties and, through the strategic design of incentive structures, actively promotes sustainable behaviors and risk-reduction practices among policyholders (Botzen & van den Bergh, 2020). At the international level, insurance schemes linked to water security and climate adaptation are increasingly regarded as indispensable components of comprehensive national adaptation strategies, performing a critical dual role. On one hand, they act as financial shock absorbers against climate-induced disasters such as droughts and floods, and on the other, they provide tangible economic incentives that facilitate the implementation of preventive and adaptive measures by individuals, industries, and governments (Surminski & Thieken, 2021; Kousky, Treuer, & Mach, 2024).

Comparative policy studies consistently indicate that insurance can serve as an effective and efficient element within broader climate risk governance systems. The pioneering work of Hellmuth et al. (2009) introduced and developed the concept of "index-based insurance" as a major innovation in this field, offering a practical and administratively efficient solution for water-dependent sectors such as agriculture and hydropower. In this transformative approach, compensation payments are triggered not by traditional, often lengthy and contentious, on-site damage assessments but by the objective realization of predefined climate or environmental indicators (e.g., rainfall levels measured at specific meteorological stations, satellite-based soil moisture data, or regional temperature thresholds). This methodology has proven particularly effective and scalable in developing countries with limited financial resources and weak institutional capacity for claims verification (Clarke & Dercon, 2020). In parallel, leading international organizations strongly emphasize that insurance should be formally considered an integral part of comprehensive, government-led disaster risk management programs related to water crises and scarcity (Global Water Partnership, 2020; UNESCO, 2023).

In advanced economies with mature financial markets, well-developed and sophisticated insurance systems have been established over decades to address natural hazards and proactively manage water resources. The U.S. National Flood Insurance Program (NFIP) is a notable and widely studied example, having played a significant role in managing flood damages and supporting the reconstruction of urban infrastructure, though it also faces challenges related to moral hazard and fiscal sustainability (Kousky, Treuer, & Mach, 2024). Likewise, in many European countries, national flood insurance systems are explicitly designed to encourage risk-reducing behavior among property owners and municipalities by offering substantial premium discounts to policyholders who undertake verified preventive measures, such as installing flood barriers or adopting water-resistant building materials, thereby contributing directly to overall loss reduction and enhanced community resilience (Hudson & Botzen, 2023).

Recent research in behavioral economics has also paid particular attention to the psychological and behavioral dimensions of insurance uptake in the context of natural hazards. Hudson and Botzen (2023) convincingly demonstrate that behavioral factors, such as risk perception, optimism bias, and trust in institutions, significantly influence the willingness of individuals and firms to purchase insurance coverage against low-probability, high-impact events. Consequently, the design of successful insurance products must strategically take into account the motivations, biases, and concerns of potential policyholders to achieve adequate market penetration. Clarke and Dercon (2020), in turn, highlight the vital role of insurance in protecting economically vulnerable groups against climate risks, framing it not just as a financial tool but as a potential instrument for advancing social justice and establishing reliable safety nets for the poor, who are often disproportionately affected by water-related disasters.

In Iran, water scarcity has escalated into one of the country's most serious and deeply entrenched structural challenges. Ahmadi et al. (2021) provide compelling evidence that climate change has placed severe and intensifying pressure on water resources, particularly in the southeastern regions of the country, where precipitation patterns have become increasingly erratic. Declining rainfall and rising temperatures have imposed serious constraints on reliable access to both surface water and groundwater resources, thereby directly jeopardizing national water security and agricultural output. Despite these critical and worsening conditions, the Iranian insurance industry has yet to take substantial, market-transforming steps toward addressing water- and climate-related risks in a systematic and scalable manner.

Existing insurance products in Iran remain largely focused on traditional domains such as life, health, and vehicle insurance, and have failed to provide comprehensive coverage for the specialized and growing risks associated with water scarcity and climate volatility. Nevertheless, a emerging body of domestic studies underscores the urgent need to develop climate-resilient and infrastructure-related insurance schemes. Ghafory-Ashtiany and Motamed (2024), in their detailed examination of the challenges facing the insurance industry in covering natural disasters like earthquakes, shed critical light on the regulatory, financial, and cultural obstacles that also apply to water-related risks. Simultaneously, these and other studies emphasize the considerable, untapped opportunities for expanding insurance activities into the domain of environmental risk management and climate adaptation within Iran, suggesting a potentially large and socially beneficial market for innovative products (Madani & Gholizadeh, 2022).

The theoretical literature further underscores the close and interdependent interconnection between insurance, effective risk governance, and socio-ecological resilience. Kousky, Treuer, and Mach (2024) conceptualize insurance as an integral part of a modern climate risk governance system, capable of reducing systemic vulnerability and enhancing resilience through its financial pooling and risk-spreading functions. From this broader perspective, insurance is not merely a technical financial instrument but also a potential mechanism for promoting intergenerational equity, encouraging proactive adaptation, and strengthening collective resilience against complex climate challenges (Clarke & Dercon, 2020). A comprehensive review of the global literature reveals that, worldwide, insurance is increasingly recognized as a key policy instrument in managing water-related crises and adapting to anthropogenic climate change. In Iran, although the physical dimensions of water scarcity and climate change have been extensively studied by hydrologists and climatologists, the specific role of insurance as a mitigation and adaptation tool in this domain has received comparatively little scholarly and policy attention. This significant research gap underscores the necessity and potential impact of the present study, which seeks to bridge hydrology, climate science, and risk finance to propose actionable solutions for Iran.

Literature Review:

The scholarly investigation into the role of insurance in water resource management and climate change adaptation has established a considerable and growing presence in the scientific literature over the past two decades. Surminski (2017), in her influential review study, compellingly demonstrated that insurance can function not only as a reactive mechanism for compensating losses after a disaster but also as an effective, proactive tool for facilitating climate change adaptation and building long-term societal resilience. This foundational research emphasizes that insurance should be regarded as an integral component of comprehensive, multi-pronged climate adaptation strategies, rather than a standalone financial product.

The pioneering study conducted by Hellmuth et al. (2009) at the International Research Institute for Climate and Society at Columbia University marked a significant advancement by formally introducing and elaborating the concept of index-based insurance for managing climate risks in agriculture and other water-dependent sectors. Their empirical findings showed that designing insurance products based on objective, transparent climate indicators can provide an efficient, low-cost, and scalable solution for compensating losses caused by covariate risks such as widespread droughts and catastrophic floods, particularly in data-scarce environments.

The Global Water Partnership (2020), in its seminal technical report on the intersection of climate insurance and water-related disaster risk management, highlighted the strategic importance of insurance as part of a holistic water governance toolkit. The report authoritatively identified insurance as a crucial element of comprehensive national and regional strategies for addressing escalating water crises and explicitly stressed its potential role in creating positive economic incentives for the adoption of sustainable water management practices among various stakeholders.

In the specialized domain of insurance economics and public policy, Michel-Kerjan and Kunreuther (2020) extensively examined the role of insurance in managing large-scale, systemic risks. They argued that well-designed, efficient insurance systems can significantly enhance a nation's economic resilience against natural disasters by scientifically distributing the burden of risk across space and time, thereby preventing localized shocks from cascading into national economic crises. Similarly, Mechler and Hochrainer-Stigler (2020) investigated the theoretical and empirical role of insurance in reducing the macroeconomic impacts of disasters, suggesting that insurance can serve as a powerful mechanism for mitigating direct and indirect losses and for strengthening the underlying resilience of the economy.

Focusing on the context of developing countries, Poudel and Botzen (2022) provided a critical analysis of public-private disaster insurance systems, extracting valuable lessons for developing nations like Iran in designing, implementing, and scaling effective and affordable insurance systems that serve both public safety and private profit motives. Mirroring this focus, Hochrainer-Stigler and Mechler (2022) emphasized the overarching importance of strategic disaster risk financing in developing countries, showing through empirical modeling that well-designed financial protection mechanisms can substantially reduce fiscal vulnerability and human suffering from natural hazards.

Clarke and Dercon (2020) brought a critical social equity dimension to the discussion by focusing their analysis on the role of insurance in protecting economically vulnerable groups. They argued persuasively that insurance, when appropriately designed and subsidized, can act as a practical tool for promoting social justice and establishing reliable financial safety nets for the poor, who are typically the most exposed and least resilient to climate risks and water shortages.

In the specific Iranian context, Ahmadi et al. (2021) conducted a rigorous study on the measurable effects of climate change on water resources in the strategically important southeastern Iran, showing through hydrological modeling that climate change has already significantly reduced water availability in this arid region, threatening rural livelihoods and regional stability. Complementing this, Ghafory-Ashtiany and Motamed (2024), in their detailed study of earthquake insurance challenges within Iran, revealed that the country's insurance industry faces serious, structural obstacles in providing coverage for natural disasters, including limited reinsurance capacity, regulatory constraints, and a lack of public risk awareness, which are also directly relevant to water-related risks (Payandeh & Rahmani, 2024). Table 2 provides a systematic overview of this literature, highlighting the limited focus on Iran-specific water insurance solutions.

Research Implementation Method:

This study employed a rigorously designed mixed-method approach to comprehensively investigate the potential integration of insurance mechanisms into Iran's water resource management and climate adaptation strategies. The methodology was specifically structured to address the complex, multi-dimensional nature of water risks, which simultaneously encompass technical, economic, social, and institutional dimensions that cannot be adequately captured through a single methodological approach (Daneshvar & Ebrahimi, 2022). The research was systematically executed in three meticulously planned and interconnected phases, each building upon the findings of the previous one to ensure a comprehensive analysis.

Table 2. Chronological analysis of key literature on water-related insurance

Year	Author(s)	Primary Focus	Geographical Context	Relevance to Iran
2009	Hellmuth et al.	Index-based agricultural insurance	Global/Developing countries	Theoretical foundation
2017	Surminski	Insurance for climate adaptation	International	Conceptual framework
2020	Clarke & Dercon	Social protection & safety nets	Developing countries	Equity considerations
2020	Botzen & van den Bergh	Flood insurance economics	Developed countries	Technical models
2020	Global Water Partnership	Water-related disaster risk management	International	Policy approaches
2021	Ahmadi et al.	Climate impacts on water resources	Iran	Problem identification
2024	Kousky et al.	Climate risk insurance scenarios	International	Scenario planning
2024	Ghafory-Ashtiany & Motamed	Natural disaster insurance challenges	Iran	Barrier analysis
2024	Payandeh & Rahmani	Climate risk & insurance industry	Iran	General assessment

First Phase: Comprehensive Literature Review and Analysis of Existing Data

The initial phase established the theoretical and empirical foundation through a systematic review of international literature and documented practices related to water and climate insurance schemes. This involved qualitative content analysis of peer-reviewed publications, policy documents, and case studies from various geographical contexts. The review critically examined successful implementations such as the U.S. National Flood Insurance Program and innovative index-based agricultural insurance systems in developing countries with climatic conditions comparable to Iran, analyzing their structural designs, implementation challenges, compensation mechanisms, and overall effectiveness in enhancing water security (Bhavani & Kumar, 2023; Güner & Şen, 2023). Concurrently, quantitative data related to Iran's insurance industry were collected from official sources, including the comprehensive statistical yearbooks published by the Central Insurance of the Islamic Republic of Iran (2022) and annual performance reports from major domestic insurance companies. These datasets were instrumental in calculating crucial metrics such as the "penetration rate of natural disaster insurance," the "share of flood and drought losses in the country's total insurance portfolio," and the "five-year trend of these indicators," providing a baseline understanding of the current insurance landscape. To ensure accuracy and comparability over time, all financial data were carefully adjusted using official inflation rates to reflect real economic values.

Second Phase: In-depth Field Study and Primary Data Collection

This phase was dedicated to gathering and analyzing primary data through multiple complementary approaches to ground the research in Iran's specific contextual realities. To quantitatively assess climate-related water risks, sophisticated modeling based on various climate scenarios was employed, drawing methodological inspiration from the study by Ahmadi et al. (2021) that examined climate change impacts on water resources in southeastern Iran. Using regional climate projections and hydrological models, various scenarios for changes in temperature, precipitation patterns, and accessibility to water resources over a 20-year future period were developed, with the model outputs used to extract quantitative risk metrics including the "probability of severe drought occurrences" and "frequency of devastating flood events" across different regions of Iran (Damavandi, 2022). Complementing the quantitative analysis, semi-structured interviews were conducted with

20 key stakeholders selected through purposive sampling to ensure representation of relevant expertise and direct experience. The participant pool included technical managers from insurance companies active in property and agricultural insurance segments, senior water sector experts from the Ministry of Energy and regional water authorities, academic specialists in environmental risk management, and representatives from environmental protection organizations. The interview protocol was carefully designed around several core thematic areas: operational definitions of water-related risks that are potentially insurable within the Iranian context; identification of technical and institutional barriers in designing and pricing such specialized insurance products; assessment of the existing capacity within Iran's insurance market and domestic reinsurance capabilities to absorb these risks; exploration of possible mechanisms to incentivize policyholders toward risk-reducing behaviors; and clarification of requirements for effective cross-sectoral collaboration between government institutions and private sector insurers. All interviews were recorded and transcribed with participants' explicit consent, and the rich qualitative data obtained were analyzed using systematic thematic analysis to identify patterns, challenges, and opportunities.

Third Phase: Integration of Findings and Development of Proposed Solutions

The final phase focused on synthesizing and integrating the quantitative and qualitative findings from the previous stages within a cohesive analytical framework. Using evidence-based design methodologies, preliminary concepts for specialized insurance instruments tailored to Iran's water sector were developed. This phase was particularly informed by the theoretical framework of index-based insurance while pragmatically considering the limitations of Iran's climate data infrastructure, as repeatedly highlighted during the stakeholder interviews. The proposed insurance products were conceptualized at three distinct levels: micro-level products designed for individual farmers and agricultural cooperatives, featuring simplified parametric triggers based on available data; mid-level products targeting water-intensive industries and manufacturing sectors, incorporating risk-based premium structures linked to water efficiency metrics; and macro-level products intended for major national water infrastructure assets, requiring more complex risk modeling and potentially involving public risk-sharing mechanisms. The development process specifically incorporated innovative approaches for integrating traditional water systems, particularly focusing on designing feasible insurance mechanisms for qanat preservation and maintenance, acknowledging their critical role in Iran's hydrological heritage and sustainable water management. The phase culminated in the formulation of a comprehensive set of policy recommendations and a preliminary implementation roadmap for integrating insurance into Iran's national water management framework, strategically designed to leverage international technical cooperation while addressing identified regulatory, financial, and cultural barriers through targeted interventions.

Results and Discussion

Current Insurance Landscape and Identified Gaps:

The comprehensive analysis of Iran's insurance market reveals a significant disparity between existing coverage and the substantial risks posed by water scarcity and climate extremes. Quantitative data from Central Insurance of the Islamic Republic of Iran (2022) indicates that insurance products specifically addressing water-related risks account for less than 2% of the total insurance market portfolio. This stands in stark contrast to developed countries with advanced climate risk management systems, where such coverage often comprises 15-20% of the insurance sector, as documented in European flood insurance markets (Schwarze & Wagner, 2020). This glaring protection gap underscores both the vulnerability of Iran's economy to water-related shocks and the substantial market potential for innovative insurance products tailored to local hydrological challenges (Ahmad & Golitzen, 2021). *This significant disparity between current coverage and potential market share is visualized in Figure 2.*

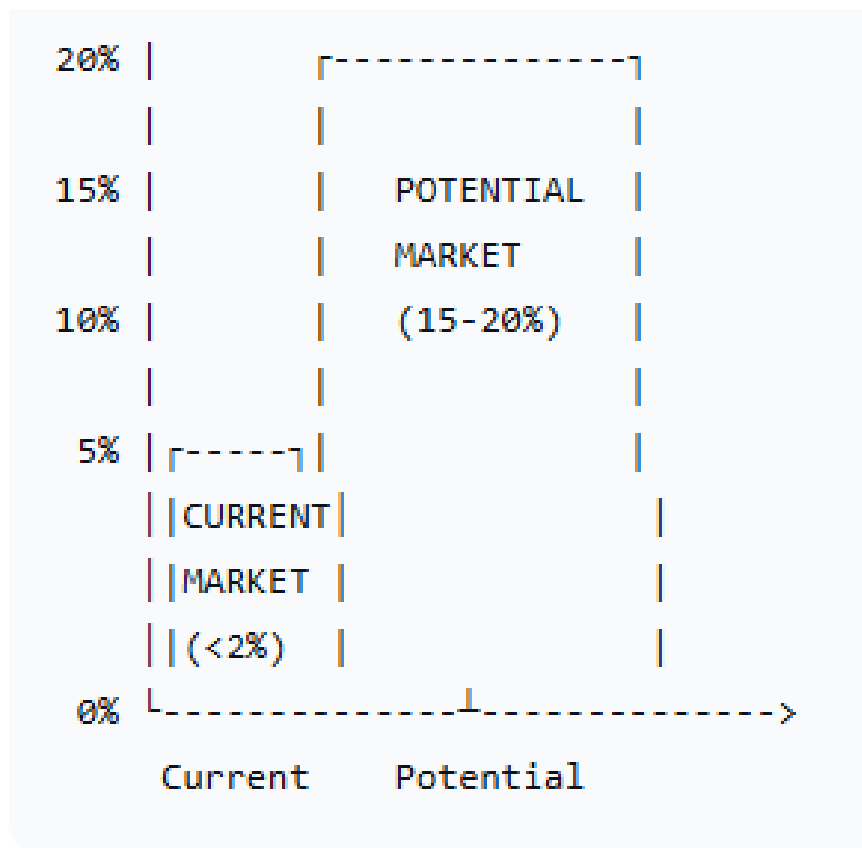


Figure 2. The water-related insurance gap in Iran's market

As visualized in Figure 2, water-related insurance currently accounts for less than 2% of Iran's total insurance portfolio, compared to a potential market share of 15-20%. This represents a 7.5 to 10-fold growth opportunity for the domestic insurance industry while addressing critical national water security challenges.

Climate Risk Projections and Insurance Implications:

Scenario-based climate modeling, building upon the foundational work of Ahmadi, Nazari, & Zare (2021), projects alarming trends for Iran's water security. Under moderate climate change scenarios, accessible water resources in critical southeastern basins could decline by up to 20% over the next two decades. These hydrological changes not only increase the probability of widespread agricultural droughts but also paradoxically heighten the risk of destructive flash floods during intense precipitation events, as observed in the devastating 2019 Golestan and Lorestan floods that caused damages estimated at several trillion tomans. The absence of comprehensive insurance coverage significantly hampered reconstruction efforts in these events, demonstrating the urgent need for pre-arranged financial protection mechanisms that can enable swift recovery and reduce fiscal pressure on government budgets and affected households (Tabari & Willems, 2023).

Stakeholder Perspectives and Implementation Barriers:

The qualitative analysis of stakeholder interviews identified four major structural barriers to developing effective water insurance markets in Iran. First, the lack of reliable and integrated climate data constitutes the most fundamental obstacle, particularly for designing sophisticated index-based insurance products that require robust historical and real-time environmental data. Second, limited technical capacity within domestic insurance companies for modeling and pricing complex water-related risks presents a significant constraint, as most insurers lack specialized expertise in hydrological risk assessment. Third, the restricted financial capacity of Iran's insurance market and challenges in accessing international reinsurance markets limit the ability to cover catastrophic losses from major drought or flood events. Fourth, an underdeveloped insurance culture and insufficient understanding of insurance as a proactive risk management tool among potential policyholders,

including agricultural producers and industrial water users, creates demand-side challenges that must be addressed through targeted education and awareness campaigns (Raschky & Weck-Hannemann, 2021).

Innovative Insurance Solutions and Implementation Pathways:

Despite these challenges, the research identifies promising pathways for developing context-appropriate insurance solutions. For the agricultural sector, index-based drought insurance offers a particularly viable approach, as demonstrated by successful implementations in comparable arid and semi-arid regions (Abrishamchi & Khazaei, 2021; Bhavani & Kumar, 2023). By triggering payouts based on objective indicators such as rainfall measurements or satellite-based vegetation indices rather than costly individual damage assessments, this model significantly reduces administrative costs and enables rapid compensation disbursement, as evidenced by programs in Kenya where farmers received payments within weeks of drought onset. To overcome Iran's data limitations, modern technologies including remote sensing and networks of low-cost automated weather stations could be deployed to create the necessary infrastructure for reliable index insurance.

For addressing capacity constraints in the domestic insurance market, the establishment of public-private risk-pooling facilities represents a promising mechanism. In this model, multiple insurers would combine their resources to cover catastrophic climate risks, while the government would provide ultimate financial backing as a reinsurer of last resort, following successful examples from developing countries with similar market conditions (Paudel & Botzen, 2022). This approach not only expands the overall risk-bearing capacity but also ensures the financial sustainability of the insurance system during extreme events that could otherwise overwhelm individual insurers.

Most innovatively, the research demonstrates that insurance mechanisms can be strategically designed to actively promote sustainable water management practices rather than merely providing post-disaster compensation. By directly linking insurance premium levels to policyholders' adoption of verified risk-reduction measures such as implementing precision irrigation systems in agriculture, investing in water recycling technologies in industry, or participating in qanat maintenance and restoration activities insurers can create powerful economic incentives for conservation and resilience-building (Surminski & Thieken, 2021). This aligns the financial interests of insurers with the broader environmental objectives of sustainable water governance, potentially transforming insurance from a passive risk-transfer mechanism into an active tool for driving positive behavioral change across water-use sectors (Sharma & Singh, 2023).

Comparative International Lessons and Adaptation to Iranian Context:

The comparative analysis of international experiences strongly suggests that the intelligent integration of insurance into holistic water governance frameworks not only enhances national resilience to water-related hazards but also contributes to reducing macroeconomic losses and accelerates societal adaptation to climate change (UNDRR, 2025). However, successful implementation in Iran will require careful contextual adaptation of these international models to account for the country's specific institutional arrangements, regulatory frameworks, and socio-cultural factors related to risk perception and insurance utilization. Specifically, initiatives should build upon existing community-based water management traditions, particularly the historical role of local water associations in maintaining qanat systems, to enhance the cultural acceptability and operational effectiveness of proposed insurance schemes (Carnegie Endowment for International Peace, 2025).

Conclusion and Recommendations

Synthesis of Key Findings:

This study conclusively demonstrates that insurance represents a crucial yet severely underutilized financial mechanism for addressing Iran's escalating water crisis. The research establishes that strategically designed insurance products can simultaneously achieve multiple objectives: providing financial protection for vital water infrastructure against climate-related damages, creating economic incentives for sustainable water use

across sectors, and mobilizing private capital for climate adaptation efforts (Botzen & van den Bergh, 2020; Surminski & Thieken, 2021). The significant gap between the substantial demonstrated potential of water insurance and its current minimal implementation in Iran underscores the urgent need for comprehensive policy reform and market development initiatives to bridge this critical protection gap.

Strategic-Level Recommendations:

- Develop and formally adopt a National Water Insurance Strategy that systematically integrates insurance mechanisms into Iran's climate adaptation policies and integrated water resource management framework. This strategy should establish clear roles for public and private stakeholders and create a coordinated implementation roadmap.
- Establish a High-Level Steering Committee comprising representatives from the Central Insurance of Iran, Ministry of Energy, Ministry of Agriculture, Department of Environment, and academic institutions to provide strategic direction and oversee the development of Iran's water insurance market.
- Implement a Phased Implementation Approach beginning with pilot programs in high-priority regions such as the Lake Urmia and Zayandeh Rud basins, where water stress is most acute and institutional capacity relatively strong, before scaling successful models nationally.

Qanat-Specific Insurance Recommendations:

- Create a Qanat Conservation Insurance Program that provides premium subsidies and enhanced coverage for communities and agricultural cooperatives that document regular maintenance and restoration activities for these traditional water systems. This program should be explicitly linked to Iran's cultural heritage preservation policies (UNESCO, 2023).
- Develop Parametric Insurance Products for Qanat Water Supply that trigger automatic payments when predefined indicators of water scarcity are met, ensuring financial support for qanat-dependent communities during drought periods without requiring complex damage assessments.
- Establish a Qanat Risk-Pooling Facility that combines resources from multiple watersheds to spread the financial risk of qanat system failures, making insurance more affordable and actuarially sound for these critical infrastructure assets.

Agricultural Water Insurance Recommendations:

- Design and launch Index-Based Drought Insurance products for major strategic crops in water-stressed regions, using satellite data and weather station networks to determine payouts based on objective indicators of water scarcity (Abrishamchi & Khazaei, 2021).
- Implement Water Efficiency-Linked Premium Structures that offer significant discounts to farmers who adopt water-saving technologies such as drip irrigation, soil moisture monitoring systems, and drought-resistant crop varieties.
- Create a Government-Backed Reinsurance Facility specifically for agricultural water risks to enhance insurer confidence and capacity to underwrite these policies, following successful models from comparable developing countries (World Bank Malaysia, 2024).

Urban and Industrial Water Insurance Recommendations:

- Develop Comprehensive Water Risk Insurance for municipalities and industrial water users that covers both infrastructure damage from floods and business interruption losses due to water shortages, with premiums calibrated to reflect the policyholder's water efficiency performance (Sheehan et al., 2023).
- Introduce Water Recycling Investment Incentives through insurance products that offer reduced premiums

for industries that implement certified water recycling and reuse systems, creating financial rewards for circular water economy practices.

- Establish Risk-Based Water Pricing Integration that aligns insurance premiums with water utility pricing structures, creating coordinated economic signals for conservation across both domains.

Implementation Framework and Institutional Recommendations:

- Create a National Water Data Infrastructure Initiative to address critical data gaps by expanding meteorological monitoring networks, developing satellite-based water resource assessment capabilities, and creating centralized databases for water risk modeling, in collaboration with World Meteorological Organization (2024) standards.
- Launch a Water Insurance Capacity Building Program for domestic insurers, reinsurers, and regulatory authorities to develop specialized expertise in hydrological risk assessment, product design, and claims management for water-related perils.
- Establish a Public-Private Water Insurance Facility with initial capitalization from government sources and subsequent private sector participation to underwrite pioneer water insurance products and demonstrate market viability.
- Implement a Stakeholder Education and Awareness Campaign to build understanding of water insurance benefits among potential policyholders, using demonstration projects and success stories from early adopters to stimulate market demand.

Future Research Priorities:

Further research should investigate hybrid insurance structures that combine traditional indemnity coverage with parametric triggers for complex water risks, building on frameworks proposed by Kousky, Treuer, and Mach (2024). Additional studies are needed to explore innovative financing mechanisms such as catastrophe bonds for water-related disasters and green bonds for water infrastructure resilience, adapting international experiences to Iran's specific context. Research should also examine the potential for integrating modern financial technology solutions, including blockchain for transparent claims settlement and remote sensing for objective loss assessment, to enhance the efficiency and trustworthiness of water insurance markets (UNDP Insurance and Risk Finance Facility, 2024; United Nations Framework Convention on Climate Change - UNFCCC, 2021).

The successful implementation of these recommendations through a coherent operational program with continuous monitoring and evaluation can transform Iran's approach to water security—not only enhancing economic and social resilience to climate challenges but also establishing the insurance industry as a strategic partner in national sustainable development. The proposed water insurance framework represents a pragmatic pathway toward climate adaptation that leverages market mechanisms while ensuring equitable protection for vulnerable communities and critical ecosystems.

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