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Analysis of Principles of Nuclear Damage Compensation in International Conventions and Customary Law

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Nuclear energy presents immense potential as a sustainable energy source but also poses significant risks of catastrophic damage in the event of accidents. Addressing the legal challenges associated with compensating for nuclear damage requires a cohesive framework that balances accountability, victim compensation, and environmental protection. This article critically examines the comparative dimensions of international conventions and customary international law governing nuclear liability. It analyzes key frameworks such as the Paris and Vienna Conventions, as well as customary principles like state responsibility and prevention of transboundary harm. The discussion highlights the similarities and differences in principles and mechanisms, including strict liability, channeled liability, and financial security. By exploring case studies such as the Chernobyl and Fukushima disasters, the article evaluates the practical application of these frameworks and their respective limitations. Attention is also given to the gaps and overlaps in current compensation mechanisms, particularly concerning transboundary impacts and environmental damages. Focusing on the Iranian context, the article identifies the gaps in legal and judicial practices, proposing reforms to enhance nuclear liability frameworks. Recommendations include the adoption of a dedicated nuclear liability act, the establishment of a national compensation fund, and the integration of traditional Islamic legal principles with international standards. The article concludes by emphasizing the importance of public awareness, regional cooperation, and global harmonization to create a more comprehensive and effective system for nuclear damage compensation. This study provides a roadmap for policymakers, legal practitioners, and international organizations to address the multifaceted challenges of nuclear liability while fostering a sustainable and equitable approach to nuclear energy development.

Keywords: *Nuclear liability, Paris Convention, Vienna Convention, Customary international law, State responsibility, Transboundary harm, Iran, Legal reform, Nuclear damage compensation, Environmental protection.*

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1. Introduction

Nuclear liability is a distinct legal domain shaped by the inherent risks and complexities associated with nuclear energy. The concept of nuclear liability addresses the legal obligations of nuclear operators and states to provide compensation for damages arising from nuclear incidents. At its core, nuclear liability law is structured to ensure swift compensation for victims while minimizing disputes over causation and fault. This

is achieved through principles like strict liability, which holds operators liable irrespective of negligence, and channeled liability, which consolidates responsibility solely on operators, thereby simplifying the legal process. These principles are designed to balance the industrial necessity of nuclear energy with the imperative to protect public welfare and environmental integrity (Yankov, 1986).

International conventions have played a pivotal role in shaping nuclear liability regimes. The Paris Convention of 1960 and the Vienna Convention of 1963, alongside their supplementary protocols, represent foundational frameworks for nuclear damage compensation. These conventions introduced standardized principles, such as capping operator liability, requiring financial security mechanisms, and delineating the jurisdiction for claims. However, they differ in scope and implementation, reflecting the varying priorities of their member states. For instance, while the Paris Convention focuses primarily on European states, the Vienna Convention has a broader geographical reach. These differences underscore the challenges of harmonizing nuclear liability laws on a global scale, a task complicated further by disparities in state capacities and legal traditions (Faure & Johnston, 2011).

The historical evolution of nuclear damage compensation frameworks reveals an ongoing effort to address the gaps and limitations of existing systems. Early nuclear liability laws were largely reactive, developed in response to specific incidents like the Chernobyl disaster in 1986. This catastrophic event exposed significant inadequacies in international and domestic legal frameworks, particularly in addressing transboundary damages. In response, efforts were made to strengthen existing conventions and introduce new mechanisms, such as the 1997 Protocol to Amend the Vienna Convention and the 1997 Convention on Supplementary Compensation for Nuclear Damage (CSC). These instruments aimed to enhance the financial resources available for compensation and broaden the geographical scope of liability. Despite these advancements, challenges remain in ensuring equitable access to compensation, particularly for affected communities in less-developed regions (Handrlica, 2020).

Customary international law has also influenced nuclear liability frameworks, particularly through the principle of state responsibility for transboundary harm. This principle, articulated in cases like the Trail Smelter arbitration and affirmed by the International Court of Justice, obligates states to prevent activities within their jurisdiction from causing harm to other states. In the context of nuclear energy, this principle underpins the obligation of states to regulate nuclear activities and ensure adequate compensation for damages. However, the interplay between customary law and treaty law is often fraught with ambiguity, especially in cases where treaties leave gaps or conflict with customary norms. This underscores the need for greater clarity and coherence in the relationship between these sources of law (Birnie et al., 2009).

Balancing state sovereignty and international accountability is a critical aspect of nuclear liability law. States possess sovereign rights to develop and utilize nuclear energy for peaceful purposes, as recognized under international frameworks like the Treaty on the Non-Proliferation of Nuclear Weapons (NPT). However, this sovereignty is accompanied by responsibilities to ensure the safe and secure operation of nuclear facilities and to prevent harm to other states. The principle of due diligence, as articulated in international environmental law, provides a basis for reconciling these rights and responsibilities. By requiring states to take all feasible measures to prevent harm, due diligence serves as a mechanism for aligning national interests with international obligations (Whiteside, 2015).

The importance of balancing these interests is particularly evident in the context of transboundary nuclear incidents. Such incidents often involve complex questions of jurisdiction, responsibility, and compensation, requiring a coordinated international response. For example, the Fukushima disaster in 2011 highlighted the limitations of existing liability frameworks in addressing the cross-border impacts of nuclear accidents. While Japan undertook significant efforts to compensate affected parties, the lack of binding international standards for transboundary compensation exposed gaps in the global legal architecture. This has prompted calls for a more integrated approach that combines the strengths of international conventions with the flexibility of customary law (Schneider et al., 2019).

In addition to legal considerations, the political and economic dimensions of nuclear liability also influence

its development. Nuclear energy is a strategic industry for many states, contributing to energy security, economic growth, and technological advancement. These considerations often shape state positions on liability issues, as evidenced by the debates over liability caps and financial security requirements. While operators argue that excessive liability could stifle innovation and investment, victim advocates emphasize the need for adequate compensation and accountability. Striking a balance between these competing interests is essential for ensuring the sustainability and legitimacy of nuclear liability regimes (Katouzian, 2006).

The theoretical framework for nuclear liability must also consider the role of non-state actors, such as insurance providers, environmental organizations, and affected communities. These actors play a critical role in shaping the implementation and evolution of liability laws. For instance, insurance mechanisms are integral to ensuring the financial viability of compensation systems, while advocacy groups contribute to raising awareness and advocating for stronger protections. The participation of these actors enhances the inclusivity and effectiveness of nuclear liability frameworks, aligning them more closely with the needs and expectations of diverse stakeholders (Yankov, 1986).

In conclusion, the theoretical framework for nuclear damage compensation reflects the interplay of legal, political, and social considerations. By integrating principles from international conventions, customary law, and state practice, this framework seeks to address the unique challenges posed by nuclear energy. However, the dynamic and evolving nature of nuclear liability law requires continuous adaptation and innovation to ensure its relevance and effectiveness. As states and international organizations grapple with emerging challenges, such as climate change and the proliferation of nuclear technology, the need for robust and equitable liability frameworks has never been more urgent. This underscores the importance of ongoing research and dialogue to refine and enhance the principles and mechanisms governing nuclear damage compensation.

2. International Conventions on Nuclear Damage Compensation

The international legal framework addressing nuclear damage compensation has evolved through a series of conventions, protocols, and supplementary instruments aimed at harmonizing state practices and ensuring equitable mechanisms for compensating affected parties. Two primary conventions underpinning this framework are the Paris Convention of 1960 and the Vienna Convention of 1963. These agreements reflect global recognition of the unique risks associated with nuclear activities and the need for robust legal mechanisms to address them.

The Paris Convention, adopted under the auspices of the Organisation for Economic Co-operation and Development (OECD), was one of the earliest international efforts to regulate nuclear damage compensation. This convention primarily applies to nuclear installations within member states of the OECD and establishes a strict liability regime. Strict liability ensures that operators are held responsible for nuclear damage without requiring proof of fault, streamlining the compensation process and protecting victims from prolonged litigation. Furthermore, the Paris Convention introduces the principle of channeled liability, consolidating responsibility solely on the nuclear operator to avoid fragmented liability among multiple entities. This approach facilitates clarity in legal claims and ensures victims have a specific entity to hold accountable (Pelzer, 2006).

In 1963, the Vienna Convention on Civil Liability for Nuclear Damage was adopted under the aegis of the International Atomic Energy Agency (IAEA). This convention aimed to provide a broader geographical scope than the Paris Convention, making it accessible to states beyond the OECD framework. Like the Paris Convention, the Vienna Convention incorporates the principles of strict and channeled liability but also establishes a minimum financial cap for operator liability. This provision ensures that victims receive adequate compensation, even if the operator's financial capacity is limited. However, critics argue that the minimum liability amounts set by the Vienna Convention are often insufficient to cover the extensive damages caused by severe nuclear accidents, such as the Chernobyl disaster (Faure & Johnston, 2011).

To address the limitations of the original conventions, several supplementary protocols have been introduced. The Brussels Supplementary Convention (1963) complements the Paris Convention by establishing additional compensation funds sourced from

contributions by states. Similarly, the 1997 Protocol to Amend the Vienna Convention significantly increases liability amounts and expands the definition of nuclear damage to include environmental restoration costs and loss of income due to environmental harm. These amendments demonstrate a progressive effort to align nuclear liability frameworks with contemporary expectations of environmental accountability (Adisianya, 2009).

The Convention on Supplementary Compensation for Nuclear Damage (CSC), adopted in 1997, represents another critical development in the international nuclear liability regime. The CSC aims to create a global compensation fund for nuclear damage, pooling resources from participating states to provide financial assurance for victims. Unlike the Paris and Vienna Conventions, which have regional or limited memberships, the CSC seeks to establish a universal framework that bridges gaps between existing liability regimes. However, the CSC has faced challenges in achieving widespread ratification, with key nuclear states such as India expressing reservations about its provisions, particularly those related to liability caps and state contributions (Schwartz, 2006).

A key feature of these conventions is the emphasis on financial security mechanisms to ensure operators can fulfill their liability obligations. Most frameworks mandate that operators maintain insurance or other financial guarantees sufficient to cover their liability. These mechanisms provide a safety net for victims while protecting operators from insolvency risks. However, the adequacy of these financial guarantees remains a contentious issue. The Fukushima disaster in 2011 revealed significant gaps in financial preparedness, as the compensation costs far exceeded the available resources under Japan's domestic liability regime. This incident highlighted the need for international conventions to establish more robust financial requirements and mechanisms for addressing catastrophic accidents (Lamm, 2006).

While the principles of strict liability, channeled liability, and financial security mechanisms enhance the effectiveness of nuclear liability frameworks, they are not without limitations. Strict liability, for instance, simplifies the claims process but may lead to inequitable outcomes in cases where the operator is not at fault. Similarly, the principle of channeled liability has been criticized for potentially shielding manufacturers and suppliers from accountability, even in cases of negligence. These limitations underscore the importance of periodically revisiting and revising liability conventions to address emerging challenges and stakeholder concerns (Kiss, 2006).

Another critical aspect of international conventions is their treatment of transboundary harm. Nuclear accidents often have cross-border impacts, necessitating mechanisms for compensating victims in affected states. Both the Paris and Vienna Conventions address transboundary harm by granting affected states jurisdiction to pursue claims and ensuring non-discriminatory treatment of foreign claimants. However, disparities in domestic implementation often undermine these provisions. For example, while some states have incorporated the conventions' principles into their national laws, others have failed to do so, creating inconsistencies in compensation processes and outcomes (Yazdanian & Habibian, 2013).

The interplay between international conventions and domestic legal systems also presents challenges. Many states have adopted national liability laws that diverge from the conventions' standards, resulting in fragmented practices and regulatory gaps. For instance, Iran's domestic liability framework incorporates elements of both Islamic jurisprudence and international law, creating unique challenges for aligning its practices with global conventions. Similarly, European states participating in the Paris Convention often face difficulties reconciling its provisions with EU regulations on environmental liability and corporate accountability (Ebrahimi Gol, 2009).

Despite these challenges, international conventions on nuclear damage compensation represent a significant achievement in harmonizing state practices and promoting global accountability. They provide a foundation for addressing the complex legal, financial, and social dimensions of nuclear accidents, offering a degree of predictability and stability in an inherently risky domain. However, the dynamic nature of nuclear technology and the increasing frequency of extreme environmental events necessitate continuous innovation and adaptation. Future reforms should focus on enhancing the inclusivity and equity of liability frameworks, particularly by incorporating provisions for

vulnerable populations and developing states (Boyle, 1990; Lesani, 2000).

In conclusion, the Paris and Vienna Conventions, along with their supplementary protocols and the CSC, constitute the core of the international legal framework for nuclear damage compensation. While these instruments have made significant strides in addressing the unique challenges posed by nuclear accidents, they remain works in progress. Ongoing efforts to harmonize liability regimes, strengthen financial security mechanisms, and address transboundary harm are essential for ensuring their continued relevance and effectiveness. As the global community grapples with the dual imperatives of expanding nuclear energy and mitigating its risks, these conventions will play a pivotal role in shaping the legal and policy responses to nuclear damage.

3. Customary International Law and Nuclear Damage Compensation

Customary international law plays a significant role in shaping the legal framework for addressing nuclear damage compensation, particularly in the absence of universally accepted conventions or when existing treaties fall short. Rooted in the practices and legal expectations of states, customary international law establishes principles that govern state conduct in cross-border activities, including those involving hazardous nuclear materials. These principles offer a foundation for addressing transboundary harm and ensuring that states fulfill their obligations to prevent, mitigate, and compensate for nuclear damages.

One of the central principles derived from customary international law is the duty to prevent transboundary harm. This principle was articulated in the Trail Smelter arbitration (1938-1941), which established the precedent that states have a responsibility to ensure that activities within their jurisdiction do not cause harm to other states. Although the case concerned industrial pollution, its relevance to nuclear damage is clear. The principle requires states to exercise due diligence in regulating and monitoring activities that pose significant risks, including those involving nuclear facilities. This obligation is reinforced by the International Law Commission's (ILC) Draft Articles on the Prevention of Transboundary Harm from Hazardous Activities, which emphasize the proactive measures states must take to avoid causing harm beyond their borders (Boyle, 1990).

Customary international law also incorporates the principle of state responsibility, which holds states accountable for internationally wrongful acts, including failures to prevent transboundary harm. This principle was codified in the ILC's Articles on State Responsibility for Internationally Wrongful Acts (2001), which outline the obligations of states to cease wrongful acts, make reparations, and guarantee non-repetition. In the context of nuclear damage, state responsibility is particularly relevant when regulatory failures or negligence contribute to nuclear accidents with cross-border consequences. For example, following the Chernobyl disaster in 1986, the Soviet Union faced significant criticism for its delayed response and inadequate measures to contain the fallout, highlighting the challenges of enforcing state responsibility in nuclear incidents (Birnie et al., 2009).

The role of customary international law becomes even more significant when compared with conventional legal frameworks, such as the Paris and Vienna Conventions. While these conventions provide detailed mechanisms for nuclear damage compensation, their applicability is often limited by geographic scope, membership, and financial caps. Customary international law, by contrast, applies universally and is not constrained by treaty boundaries. This universality makes it a vital tool for addressing nuclear damage in regions where treaty regimes are weak or non-existent. However, the reliance on state practice and opinio juris (a belief that an action is legally obligatory) to establish customary norms can lead to ambiguities and inconsistencies, particularly in complex and politically sensitive areas like nuclear liability (Pelzer, 2006).

One of the key challenges in applying customary international law to nuclear damage compensation lies in the enforcement of its principles. Unlike treaty law, which relies on explicit agreements and institutional mechanisms, customary law depends on state practice and consensus. This reliance can hinder the timely and effective resolution of disputes, as states may contest the interpretation or applicability of customary norms. For instance, in the aftermath of the Fukushima disaster, neighboring countries such as South Korea and China raised concerns about the transboundary impacts of radioactive discharge into the Pacific Ocean. While

customary principles of prevention and state responsibility could have provided a basis for addressing these concerns, the lack of binding enforcement mechanisms limited their practical application (Schwartz, 2006).

Another challenge stems from the complexity of establishing causation and liability in nuclear damage cases. Nuclear accidents often involve multiple actors, including operators, regulators, and international organizations, making it difficult to attribute responsibility solely to states. Customary international law's focus on state obligations can thus leave significant gaps in addressing the full spectrum of liabilities. In contrast, conventional legal frameworks like the Paris and Vienna Conventions channel liability to operators, simplifying the claims process. However, this approach may not adequately account for the broader systemic failures that contribute to nuclear incidents, highlighting the need for a more integrated approach that combines the strengths of both customary and conventional frameworks (Faure & Johnston, 2011).

Despite these challenges, customary international law offers valuable flexibility and adaptability in addressing nuclear damage compensation. Its principles can complement treaty regimes by filling gaps and providing a broader normative framework for state conduct. For example, the principle of equitable utilization, which requires states to use shared resources in a manner that respects the rights and interests of other states, can inform the development of compensation mechanisms for transboundary nuclear harm. Similarly, the precautionary principle, widely recognized in international environmental law, emphasizes the need to take preventive measures in the face of scientific uncertainty, reinforcing the obligation of states to prioritize safety and risk mitigation in nuclear activities (Kiss, 2006).

The relationship between customary international law and conventional legal frameworks is further complicated by the diversity of state practices and legal systems. In Iran, for instance, the legal framework for nuclear damage compensation incorporates elements of Islamic jurisprudence, which emphasizes restitution and equity. While these principles align with certain aspects of customary international law, such as the obligation to make reparations, they also introduce unique challenges in harmonizing domestic practices with international norms. Similarly, the dual legal systems in countries like India and South Africa, which combine common law and statutory frameworks, create additional complexities in aligning customary and conventional approaches to nuclear liability (Ebrahimi Gol, 2009).

A significant advantage of customary international law is its potential to address emerging challenges in nuclear liability that are not yet covered by treaty regimes. For instance, the increasing use of small modular reactors (SMRs) and the expansion of nuclear energy in developing countries raise new questions about risk allocation, regulatory capacity, and financial responsibility. Customary principles of due diligence, equitable utilization, and state responsibility can provide a flexible foundation for addressing these challenges, particularly in regions where treaty adoption and implementation are limited. However, the effective application of these principles requires greater international cooperation and consensus-building, as well as the development of institutional mechanisms to support their enforcement (Faure & Johnston, 2011).

In conclusion, customary international law plays a critical role in shaping the global framework for nuclear damage compensation. Its principles of prevention, state responsibility, and equitable utilization complement conventional legal frameworks and provide a universal normative basis for addressing transboundary nuclear harm. However, the challenges of enforcement, ambiguity, and systemic complexity highlight the need for greater integration and harmonization between customary and treaty regimes. As nuclear technology continues to evolve, the adaptability and universality of customary international law will remain essential for addressing the legal and ethical dimensions of nuclear energy and its associated risks.

4. Comparative Analysis: Conventions vs. Customary Law

The frameworks for nuclear damage compensation under international conventions and customary international law share common goals but differ significantly in principles, approaches, and mechanisms. Both aim to provide a legal basis for addressing nuclear accidents, ensuring accountability, and compensating victims. However, their distinct origins and scopes influence their applicability and effectiveness,

particularly when addressing complex cases of nuclear harm.

A primary similarity between international conventions and customary international law lies in their shared emphasis on state responsibility and victim compensation. Both frameworks recognize that states, as the primary actors in international law, have a duty to regulate and oversee nuclear activities within their territories. This duty includes ensuring the safety of nuclear facilities and compensating for damages caused by nuclear accidents. For instance, the principle of state responsibility in customary law aligns with the provisions of the Paris and Vienna Conventions, which obligate states to enforce liability regimes for nuclear operators under their jurisdiction (Birnie et al., 2009).

Despite these similarities, key differences emerge in the principles and approaches of these frameworks. Conventions like the Paris and Vienna Conventions focus on strict liability and channeled liability, where nuclear operators are held accountable irrespective of fault, and liability is centralized on the operator rather than the state. This approach simplifies legal processes and ensures that victims have a clear entity to seek compensation from. In contrast, customary international law emphasizes the broader principle of state responsibility, holding states accountable for failures to prevent transboundary harm or regulate nuclear activities effectively. This distinction reflects the divergent priorities of the two frameworks: while conventions prioritize operational accountability, customary law underscores the regulatory and supervisory obligations of states (Pelzer, 2006).

Another significant difference lies in the scope of application. International conventions are treaty-based and apply only to their signatories, creating a fragmented legal landscape. For example, the Paris Convention primarily applies to European OECD member states, while the Vienna Convention has a broader but still limited geographical reach. In contrast, customary international law is universal, binding all states regardless of their treaty commitments. This universality makes customary law a vital tool for addressing nuclear damage in regions not covered by conventional frameworks, such as parts of Africa and the Middle East. However, the reliance on state practice and opinio juris to establish customary norms can lead to inconsistencies and ambiguities, complicating their application (Schwartz, 2006).

Case studies highlight the practical implications of these differences. The Chernobyl disaster in 1986 provides a stark example of the limitations of conventional frameworks. The Soviet Union, as a non-signatory to the Paris and Vienna Conventions, was not bound by their provisions, leaving affected states reliant on customary international law to address transboundary harm. While the principle of state responsibility provided a basis for claims, the lack of enforcement mechanisms and clear legal standards hindered effective resolution. This case underscores the importance of integrating customary principles with treaty-based regimes to address gaps in coverage and ensure accountability (Faure & Johnston, 2011).

In contrast, the Fukushima disaster in 2011 demonstrates the strengths and weaknesses of conventional frameworks. Japan, as a party to the Vienna Convention, was obligated to implement a strict liability regime for nuclear operators. This framework facilitated compensation for domestic victims but struggled to address transboundary harm, as neighboring countries like South Korea and China were not directly covered by the convention. This limitation highlights the need for greater harmonization between conventions and customary law to address cross-border impacts comprehensively (Lamm, 2006).

The differences between conventions and customary law also extend to their mechanisms for compensation. International conventions often establish financial caps on liability, requiring operators to maintain insurance or financial guarantees to cover their obligations. While these mechanisms provide predictability and financial security, they may be insufficient to address the extensive damages caused by severe nuclear accidents. For instance, the compensation caps under the Paris and Vienna Conventions were criticized as inadequate in the wake of Chernobyl and Fukushima, prompting calls for reforms to increase liability limits and enhance financial assurance mechanisms (Schwartz, 2006).

Customary international law, by contrast, does not impose specific financial caps, relying instead on the principle of full reparation to determine compensation amounts. This principle, articulated in the ILC's Articles on State Responsibility, obligates states to restore victims to their pre-incident position as far as possible.

While this approach is more flexible and equitable, its practical implementation is often hindered by the lack of institutional frameworks and financial resources. The reliance on state practice and negotiations to determine compensation can lead to delays and inconsistencies, particularly in cases involving multiple states and stakeholders (Kiss, 2006).

A critique of both frameworks reveals significant gaps and overlaps that undermine their effectiveness. One major gap is the lack of comprehensive coverage for transboundary harm. While both conventions and customary law recognize the principle of non-discrimination in compensation, their practical application is often constrained by jurisdictional and procedural barriers. For example, affected communities in non-signatory states may face difficulties pursuing claims under conventional frameworks, while customary law's reliance on state-to-state negotiations can leave individual victims without adequate remedies (Pelzer, 2006).

Another gap is the limited integration of environmental considerations into nuclear liability regimes. Conventional frameworks, such as the Paris and Vienna Conventions, historically focused on human and property damages, with limited provisions for environmental restoration. Recent amendments, such as the 1997 Protocol to Amend the Vienna Convention, have sought to address this gap by expanding the definition of nuclear damage to include environmental harm. However, these efforts remain incomplete, as many states have yet to ratify the amendments. Customary international law, with its emphasis on the principle of equitable utilization and environmental protection, offers a complementary perspective but lacks the institutional mechanisms to enforce these principles effectively (Boyle, 1990).

Overlaps between conventions and customary law also create challenges, particularly in cases where their provisions conflict or create ambiguities. For instance, the principle of channeled liability under conventional frameworks may conflict with the broader accountability of states under customary law. This conflict raises questions about the respective roles and responsibilities of operators and states, particularly in complex cases involving regulatory failures or systemic negligence. Addressing these overlaps requires greater harmonization and coordination between the two frameworks, including the development of joint protocols and guidelines to clarify their relationship and ensure consistency (Faure & Johnston, 2011).

In conclusion, the comparative analysis of conventions and customary international law reveals both their strengths and limitations in addressing nuclear damage compensation. While international conventions provide detailed mechanisms and institutional support, their limited scope and financial caps constrain their effectiveness. Customary international law, with its universal applicability and emphasis on state responsibility, offers a broader normative framework but faces challenges in enforcement and practical implementation. Case studies such as Chernobyl and Fukushima highlight the need for greater integration and harmonization between these frameworks to address the complex and transboundary nature of nuclear harm. Moving forward, efforts to strengthen nuclear liability regimes should focus on bridging gaps, enhancing financial mechanisms, and aligning conventional and customary principles to ensure equitable and comprehensive compensation for victims.

5. Policy Recommendations and Future Directions

Addressing the complexities and challenges of nuclear damage compensation requires a forward-looking approach that bridges gaps in legal and judicial practices. In the Iranian context, the interplay of domestic law, Islamic jurisprudence, and international frameworks poses unique challenges that necessitate a tailored strategy for reform. To ensure a robust and effective system of nuclear liability, it is essential to identify the existing gaps, propose meaningful reforms, and balance traditional and modern legal principles.

One of the critical gaps in the Iranian legal framework lies in the lack of comprehensive legislation specifically addressing nuclear damage compensation. Although Iran is a signatory to international conventions on nuclear safety and liability, these agreements often require complementary domestic laws for effective implementation. Existing Iranian laws, such as the Civil Liability Act and related provisions in Islamic jurisprudence, provide a general framework for addressing damages. However, they lack specificity in dealing with the unique aspects of nuclear harm, such as transboundary impacts, long-term environmental damage, and the need for rapid compensation

mechanisms. The absence of clear procedural guidelines and enforcement mechanisms further exacerbates these challenges, leaving victims with limited recourse (Ebrahimi Gol, 2009).

Judicial practices in Iran also face significant challenges in addressing nuclear damage cases. Courts often lack the technical expertise to evaluate the complex scientific and legal dimensions of nuclear incidents. This limitation can lead to inconsistencies in judicial decisions, undermining public trust in the legal system. To address this issue, it is essential to establish specialized judicial bodies or panels with expertise in nuclear liability. These panels could include judges, legal scholars, and technical experts who can work collaboratively to adjudicate nuclear damage claims effectively. Additionally, judicial training programs focusing on nuclear liability and international legal standards should be developed to enhance the capacity of judges and legal practitioners (Yazdanian & Habibian, 2013).

Reforming nuclear liability laws in Iran requires a comprehensive approach that addresses both substantive and procedural aspects. One key proposal is the adoption of a dedicated nuclear liability act that incorporates the principles of strict liability and financial security mechanisms. This act should align with international conventions while reflecting Iran's unique legal and cultural context. For instance, the act could integrate provisions for no-fault compensation schemes, ensuring that victims receive prompt redress regardless of the operator's culpability. Such provisions would align with the Islamic principle of equity and the broader objectives of restorative justice in Iranian legal culture (Rahimi, 1996).

Another critical reform is the establishment of a national nuclear compensation fund. This fund could be financed through contributions from nuclear operators, insurance premiums, and state resources. The fund would serve as a financial safety net, ensuring that victims are compensated even in cases where the operator's financial resources are insufficient. This approach has been successfully implemented in other jurisdictions and could provide a model for Iran. However, the fund's governance and administration must be transparent and accountable to prevent misuse and ensure equitable distribution of resources (Farahi, 2005).

Balancing traditional and modern legal principles is essential to ensure the legitimacy and acceptance of nuclear liability reforms in Iran. Islamic jurisprudence, which forms the foundation of Iran's legal system, emphasizes the principles of justice, equity, and restitution. These principles can be harmonized with international legal standards to create a framework that reflects both local values and global norms. For example, the concept of diya (blood money) in Islamic law, which provides compensation for harm caused by wrongful acts, could be adapted to address nuclear damage. By integrating such traditional principles into modern liability frameworks, Iran can ensure that its legal system remains culturally relevant while meeting international expectations (Katouzian, 2006).

The integration of environmental considerations into nuclear liability laws is another area requiring attention. Nuclear incidents often result in significant environmental damage, which can have long-term consequences for public health and biodiversity. Existing Iranian laws, such as the Environmental Protection Act, provide a general framework for addressing environmental harm but do not specifically address nuclear-related damages. To fill this gap, nuclear liability laws should include provisions for environmental restoration, monitoring, and compensation. These provisions should be informed by the precautionary principle and the polluter-pays principle, which are well-established in international environmental law and compatible with Islamic ethical principles (Baqali, 2016).

Public awareness and engagement are also critical to the success of nuclear liability reforms. Many of the challenges in implementing liability frameworks stem from a lack of public understanding of nuclear risks and compensation mechanisms. Educational campaigns and outreach programs can play a vital role in raising awareness and building public trust in the legal system. These programs should focus on informing citizens about their rights, the responsibilities of nuclear operators, and the avenues available for seeking compensation in the event of an accident (Badini & Nazer, 2014).

Future directions for nuclear liability in Iran should also consider the role of regional and international cooperation. Nuclear incidents often have transboundary impacts, requiring collaborative efforts to address their consequences effectively. Iran could take a leadership role in promoting regional agreements on nuclear safety and liability, fostering dialogue and

cooperation with neighboring states. These agreements could include provisions for information sharing, joint emergency response mechanisms, and harmonized liability standards. By engaging with regional and international partners, Iran can strengthen its nuclear liability framework and contribute to global efforts to ensure the safe and responsible use of nuclear energy (Lesani, 2000).

In conclusion, addressing the gaps in Iran's legal and judicial practices requires a comprehensive and multi-faceted approach. By adopting a dedicated nuclear liability act, establishing specialized judicial bodies, and creating a national compensation fund, Iran can enhance its capacity to address nuclear damage effectively. Balancing traditional Islamic principles with modern legal standards will ensure the legitimacy and cultural relevance of these reforms. Moreover, integrating environmental considerations, promoting public awareness, and fostering regional cooperation will strengthen Iran's nuclear liability framework and contribute to global efforts to ensure nuclear safety. These reforms represent a critical step towards building a robust and equitable system for nuclear damage compensation that aligns with both national priorities and international obligations.

6. Conclusion

The complexities of nuclear damage compensation require a cohesive legal framework that effectively balances accountability, victim compensation, and environmental protection. The comparative analysis of international conventions and customary law reveals the strengths and limitations of both approaches, underscoring the need for a harmonized and comprehensive system. While conventions offer structured mechanisms and institutional support, customary law provides universality and flexibility, making it a critical component in addressing gaps and transboundary impacts.

For Iran, the path forward involves bridging existing gaps in legal and judicial practices, aligning domestic laws with international standards, and integrating cultural and religious principles into modern legal frameworks. Establishing a dedicated nuclear liability act, creating a national compensation fund, and enhancing judicial expertise are essential steps in ensuring a robust and equitable system. Furthermore, the inclusion of environmental considerations and the promotion of public awareness will strengthen the societal and ecological resilience against nuclear risks.

The journey towards an effective nuclear liability regime also necessitates regional and international cooperation, as nuclear incidents often transcend national borders. By fostering dialogue and partnerships, Iran can play a pivotal role in shaping the global discourse on nuclear safety and liability. These efforts will not only enhance domestic preparedness and accountability but also contribute to a safer and more sustainable nuclear energy landscape globally. Through these measures, a balanced approach that respects traditional values while embracing modern legal principles can be achieved, ensuring justice and security for all stakeholders involved.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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