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Posted Date: 27 December 2024

doi: 10.20944/preprints202410.2112.v3

Keywords: Indigenous Knowledge Systems; AI Governance; Ethical Frameworks; Māori Perspectives; Navajo Perspectives; Community Engagement; Environmental Stewardship; Data Sovereignty; Cultural Sensitivity; Relational Accountability; Kaitiakitanga, Hózhó; Stakeholder Engagement; Social Justice; Sustainable Technology; Ethical AI Practices; Capacity Building; Community Welfare; Ecological Balance; Technology Development; Inclusivity; Historical Injustices; Communal Knowledge; Collective Rights

 doi:10.20944/preprints202410.2112.v3

Article

Incorporating Indigenous Knowledge Systems into AI Governance: Enhancing Ethical Frameworks with Maori and Navajo Perspectives

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Abstract: This paper addresses a significant gap in AI governance by examining the limitations of Western-centric ethical frameworks through a comparative analysis of Māori Kaitiakitanga and Navajo Hózhó principles. While prior research emphasizes the role of Indigenous knowledge in AI, this study transcends general calls for inclusion by providing a concrete framework for integrating these principles into AI governance. The analysis juxtaposes Indigenous perspectives on collective data ownership, ecological stewardship, and relational accountability against prevailing AI ethical norms, uncovering critical shortcomings in current frameworks regarding Indigenous priorities. It draws on specific examples from Māori environmental management and Navajo health initiatives. This research illustrates how Kaitiakitanga and Hózhó can enhance data sovereignty, ecological sustainability, and community-driven decision-making in AI governance. The study proposes culturally relevant AI governance frameworks by highlighting the unique contributions of each Indigenous knowledge system and identifying common ground. Additionally, it examines the synergies and tensions between Indigenous values and principal AI ethical frameworks—such as fairness, accountability, and transparency—resulting in targeted recommendations for incorporating Indigenous perspectives into AI governance. Suggested strategies include mandated Indigenous representation in AI policymaking, culturally appropriate data governance protocols, and community-led impact assessment frameworks. Ultimately, the paper argues that including Indigenous knowledge systems in AI governance is essential for fostering cultural sensitivity and developing a more comprehensive ethical approach to AI. This research aims to cultivate a more inclusive and equitable AI landscape that honors the rights and values of Indigenous peoples while leveraging their insights to address complex ethical dilemmas in AI governance.

Keywords: AI governance; indigenous knowledge systems; Kaitiakitanga; Hózhó; data sovereignty

1. Introduction

The rapid advancement of artificial intelligence (AI) has ushered in a new era of technological possibilities, transforming industries and reshaping how we live and work (Li, 2020; Pal et al., 2023; Vinothkumar & Karunamurthy, 2023). However, this transformative power is profoundly responsible for ensuring AI is developed and deployed ethically, equitably, and sustainably (Putri & Tran, 2023). This necessitates robust AI governance frameworks that can address the complex ethical challenges posed by AI, from algorithmic bias and data privacy to the societal impact of automation and the existential risks of unchecked AI development (Renda, 2019). While numerous efforts are underway to establish such frameworks, they often reflect a predominantly Western-centric perspective, overlooking the valuable insights and ethical traditions of Indigenous knowledge systems (Ayana et al., 2024; Grancia, 2024; Nemorin, 2024; Varanasi, 2021).

Indigenous communities worldwide have long cultivated sophisticated systems of knowledge that emphasize interconnectedness, reciprocity, and long-term stewardship (Datta, 2024; Jamieson, 2010; Mazzocchi, 2020). These perspectives offer crucial guidance for navigating the ethical complexities of AI in a manner that prioritizes community well-being, environmental sustainability,

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and intergenerational equity (Carpena-Méndez et al., 2022). By integrating Indigenous knowledge into AI governance, we can move beyond narrow Western-centric ethical paradigms and develop more holistic and inclusive frameworks that respect diverse cultural values and promote a more just and sustainable technological future (Curtis et al., 2024; Mehta et al., 2024; Mokoena, 2023; Moleka, 2024).

This paper focuses specifically on two distinct Indigenous knowledge systems: the Māori concept of Kaitiakitanga and the Navajo principle of Hózhó. Kaitiakitanga embodies a deep sense of guardianship and responsibility for the well-being of the natural world and future generations (Paul-Burke & Rameka, 2015). At the same time, Hózhó emphasizes harmony, balance, and the interconnectedness of all things (Haskie, 2002). By exploring the core principles of these traditions and examining their practical applications, we aim to demonstrate their relevance to AI governance and identify concrete ways to incorporate them into ethical frameworks.

Ultimately, this paper argues that integrating Indigenous knowledge systems into AI governance is not merely a matter of cultural sensitivity but a necessity for creating a more ethical, responsible, and sustainable AI landscape. Through a comparative analysis of Kaitiakitanga and Hózhó, we will demonstrate how these Indigenous perspectives can enhance existing AI governance approaches and contribute to a more inclusive technological future that respects the rights and values of all communities.

2. Literature Review

2.1. Indigenous Knowledge Systems and AI

Indigenous communities worldwide hold diverse and sophisticated knowledge systems that offer unique perspectives on the relationship between humanity, the natural world, and technology (Barnhardt & Kawagley, 2005; Sillitoe, 1998; Snively & Corsiglia, 2001). These systems developed over millennia through direct environmental interaction and passed down through generations, emphasizing interconnectedness, reciprocity, and long-term stewardship (Jamieson, 2010; Kealiikanakaoleohaililani & Giardina, 2016). Examples of such systems include the concept of Buen Vivir in Andean South America, which emphasizes harmonious living with nature and community well-being, and the Aboriginal Australian concept of Caring for Country, which highlights responsibility for land management and intergenerational sustainability (Mero-Figueroa et al., 2020; Woodward et al., 2020). In the context of AI, these perspectives offer invaluable guidance for navigating the complex ethical challenges posed by this rapidly evolving technology.

Recent research has highlighted the potential of Indigenous knowledge to contribute to AI development in several crucial ways. Firstly, AI can serve as a powerful tool for digitizing and revitalizing Indigenous languages, stories, and traditional knowledge, ensuring their preservation and accessibility for future generations (Masenya, 2023; Nanduri, 2024; Pinhanez et al., 2024; Zou & Lin, n.d.). This not only helps to maintain cultural heritage but also allows Indigenous communities to actively participate in shaping the future of AI (Pisoni et al., 2021). For example, the Endangered Languages Project utilizes AI to document and revitalize endangered Indigenous languages, while the Māori tribal group Ngāti Whātua Ōrākei uses AI to preserve and share their cultural heritage through interactive digital platforms (Camacho & Zevallos, 2020; Williams, 2020).

Secondly, Indigenous wisdom, with its emphasis on ecological consciousness, respect for diverse worldviews, and social justice principles, can inform the design of AI algorithms to avoid biases, prioritize sustainability, and promote equitable outcomes (Ahmed et al., 2024; Fernández Fernández, 2022; Ofosu-Asare, 2024). This is essential to ensure that AI systems are developed and deployed in a manner that is both ethical and culturally sensitive. For instance, researchers are exploring the use of Indigenous knowledge to develop AI systems for environmental monitoring and resource management that respect Indigenous land rights and traditional ecological practices (Al-Mansoori & Hamdan, 2023; Gordon et al., 2023; Molino, 2023).

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Finally, AI can be used to integrate Indigenous knowledge with scientific data to address complex environmental challenges, such as climate change adaptation and sustainable resource management (Chakravarty & Gattupalli, 2024; Nishant et al., 2020). This integration can lead to more effective and adaptive management strategies that benefit both Indigenous communities and the environment. For example, the work of Sebastián Lehuedé explores the intersection of Indigenous knowledge and AI in addressing land management challenges faced by Indigenous communities in Chile (Lehuedé, 2024a, 2024b). Lehuedé's research highlights the potential of AI to support Indigenous-led initiatives in land stewardship and resource governance, while also emphasizing the importance of ensuring that AI technologies are developed and deployed in a culturally appropriate and respectful manner (Lehuedé, 2023; Vidal & Dias, 2016). Another example is the application of AI in partnership with Indigenous communities in the Amazon rainforest to monitor deforestation and protect biodiversity (Asif et al., 2023; Causevic et al., 2024; Raihan, 2023). This approach combines cutting-edge technology with traditional ecological knowledge to create more effective conservation strategies.

2.2. Incorporating Indigenous Knowledge into AI Governance

Integrating Indigenous knowledge into AI governance ensures that AI systems respect Indigenous values, rights, and interests (Hooper & Oyege, 2024). This can be achieved through various approaches. Two-Eyed AI integrates Indigenous knowledge and Western scientific perspectives, balancing ethical considerations with technological advancements (Habash, 2024; Kroeker, 2022). For example, in healthcare, Two-Eyed AI could involve using AI to analyze patient data while incorporating Indigenous healing practices for holistic care (Silano, 2024). Indigenous-led AI development empowers Indigenous communities to shape technologies affecting their lives, ensuring alignment with community values and addressing data sovereignty. An example is the development of AI-powered language learning tools by Indigenous communities in Canada to revitalize and preserve their languages (Ajani et al., 2024). Community-based participatory research involves collaborating with Indigenous communities throughout the AI lifecycle, ensuring that AI systems are developed responsively to their needs and concerns (Kankanamge et al., 2024; Sahota, 2010). For instance, a project in New Zealand involves Māori communities working with researchers to develop AI applications for environmental monitoring that align with Māori values (Barnes et al., 2021; Cherrington et al., 2020; Reid et al., n.d.).

Furthermore, Indigenous-led AI development initiatives are crucial for ensuring that AI technologies align with Indigenous values and priorities. The work of Jason Edward Lewis, a University of Toronto professor and co-director of the Indigenous Futures Research Centre, exemplifies this approach. Lewis advocates for Indigenous-led AI development that empowers Indigenous communities to shape the technologies affecting their lives, ensuring that AI respects Indigenous knowledge systems and promotes Indigenous self-determination (Baudemann, 2021; Igloliorte & Taunton, 2022; Ryan, 2023). Similarly, Angie Abdilla, a Torres Strait Islander woman and AI researcher, emphasizes the importance of Indigenous data governance and the development of AI systems that empower Indigenous communities (Abdilla et al., 2021; Van Den Hoven et al., 2020). In New Zealand, Te Hiku Media is a Māori-led organization that has developed AI-powered language learning tools to revitalize and preserve the Māori language (Jones et al., 2023; Munn, 2024). These examples demonstrate the potential of Indigenous-led AI development to create AI technologies that are both innovative and culturally responsive.

2.3. The Ethical Dimensions of AI Governance

The ethical dimensions of AI governance are multifaceted and complex, demanding careful consideration and proactive strategies to mitigate potential risks (Patel, 2024). AI systems, while offering tremendous potential benefits, can also perpetuate and amplify existing societal biases, leading to discriminatory outcomes in various domains (Keles, 2023; Modi, 2023; Scatiggio, 2020). The vast amounts of data required to train AI models raise serious concerns about individual privacy

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and the potential for misuse of personal information (Manheim & Kaplan, 2019). Furthermore, the increasing automation capabilities of AI have sparked anxieties about job displacement and the need for workforce transitions (George, 2024; West, 2018).

The "black box" nature of many AI algorithms, which often obscures the decision-making process, raises concerns about accountability and the potential for unintended consequences (Busuioc, 2021; Murad, 2021; Tschider, 2020). Moreover, the substantial computational resources required to train and deploy AI models can have a significant environmental impact, contributing to increased energy consumption and carbon emissions (Alzoubi & Mishra, 2024; Wu et al., 2022). Addressing these ethical challenges necessitates a comprehensive approach that involves developing robust ethical guidelines and standards for AI development, promoting transparency and explainability in AI algorithms, and ensuring diversity and inclusion in the AI workforce to mitigate bias. Prioritizing data privacy and security in AI systems is paramount, as is investing in research and development of AI for social good and environmental sustainability (Foffano et al., 2023).

However, conventional approaches to AI ethics often fall short of addressing the unique concerns and values of Indigenous communities. For example, the emphasis on individual privacy in Western ethical frameworks may not fully align with Indigenous concepts of collective ownership and data sovereignty (Hummel et al., 2021; Tsosie, 2019). In many Indigenous cultures, data is not seen as an individual possession but as a collective resource that belongs to the community as a whole (Brown, 2009; Gervais, 2003; Posey & Dutfield, 1996). This perspective challenges the notion of individual consent and control over data, highlighting the need for AI governance frameworks that recognize and respect Indigenous data sovereignty.

Furthermore, the potential for AI to exacerbate existing societal biases raises concerns about its impact on Indigenous communities, who already face systemic discrimination and marginalization (Bose, 2025; Raza, 2022). AI algorithms trained on biased data can perpetuate and amplify these biases, leading to unfair and discriminatory outcomes for Indigenous peoples (Lewis, 2024). This underscores the importance of incorporating Indigenous knowledge and perspectives into the design and development of AI systems to ensure that they are fair, equitable, and culturally sensitive.

The environmental impact of AI also raises concerns from an Indigenous perspective (Molino, 2023). Many Indigenous cultures deeply connect to the land and prioritize environmental sustainability (Clarkson et al., 1992; Garnett et al., 2018; Gordon et al., 2023). The energy consumption and carbon emissions associated with AI development and deployment can threaten the delicate balance of ecosystems and undermine Indigenous efforts to protect the environment. This highlights the need for AI governance frameworks that prioritize environmental sustainability and consider the long-term ecological consequences of AI technologies.

The drawbacks of current AI systems raise additional ethical concerns. For instance, the increasing prevalence of large language models (LLMs) has the potential to create language hegemonies, where dominant languages are further amplified and marginalized languages are further disadvantaged (Ovalle, 2024; Peng, 2024; Smart et al., 2024). This raises concerns about cultural diversity and the preservation of Indigenous languages. Additionally, the substantial computational resources required to train and deploy AI models, particularly the energy consumption of data centers, contribute to environmental harm (Beloglazov et al., 2012; Robertson & Romm, 2002). This raises concerns about the sustainability of AI and its impact on the natural world, which is particularly relevant to Indigenous communities who have a deep connection to the land and prioritize environmental stewardship.

2.4. Existing AI Governance Frameworks and Their Limitations

Numerous organizations and governments are actively developing AI governance frameworks to address the ethical challenges and societal implications of AI. These frameworks typically encompass a range of principles, guidelines, and best practices aimed at promoting responsible AI development and deployment. For example, the European Union's AI Act proposes a risk-based approach to regulating AI, categorizing AI systems based on their potential for harm and imposing

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stricter requirements for high-risk applications (Ebers, 2024; Korshenko, 2024). The OECD Principles on AI, adopted by many countries, promote human-centered AI that respects human rights, democracy, and the rule of law (Nikolinakos, 2023; Rotenberg, 2024). Other notable frameworks include the Asilomar AI Principles, which focus on long-term safety and ethical considerations, and the Montreal Declaration for Responsible AI, which emphasizes human well-being, autonomy, and justice (Buruk et al., 2020; Gábor, n.d.).

However, despite the growing number of AI governance frameworks, many fall short in addressing the unique needs and perspectives of Indigenous communities. The EU AI Act, while comprehensive, has been criticized for not adequately addressing Indigenous concerns regarding data sovereignty and cultural heritage protection (Madsen, 2022; Moerel & Timmers, 2021). Its primary focus on individual rights and autonomy may overlook the collectivist worldview prevalent in many Indigenous cultures, where collective well-being and decision-making are prioritized. This individualistic bias can perpetuate the marginalization of Indigenous communities and undermine their self-determination.

Similarly, the OECD Principles, while advocating for human-centered AI, may not fully capture the nuances of Indigenous perspectives on human-nature relationships and the interconnectedness of all beings (Aaronson, 2022; Runde et al., 2022). These principles, rooted in Western philosophical traditions, may not adequately address the spiritual and cultural dimensions of AI and its potential impact on Indigenous communities.

Furthermore, existing frameworks may not adequately address the unique challenges Indigenous communities face regarding data sovereignty and the protection of cultural heritage in the context of AI (Gupta et al., 2020; Kukutai et al., 2020; Marley, 2019; Nicholas, 2022; Wagner & de Clippele, 2023). Indigenous data is often intertwined with cultural identity, traditional knowledge, and sacred practices, requiring specific safeguards and governance approaches that respect Indigenous rights and self-determination (Kuokkanen, 2019; Shepard, 2015). The failure to adequately address these concerns can result in the misuse or exploitation of Indigenous data, leading to further cultural harm and erosion of Indigenous sovereignty.

The limitations of current AI governance frameworks highlight the urgent need for greater inclusion of Indigenous perspectives. By incorporating Indigenous knowledge and values, we can create more robust and culturally appropriate frameworks that ensure AI benefits all members of society, including Indigenous communities. This requires Indigenous communities' active participation in AI governance processes and a willingness to learn from their unique perspectives and experiences.

2.5. Māori Kaitiakitanga and Navajo Hózhó: Core Principles and Applications

Māori Kaitiakitanga and Navajo Hózhó represent distinct yet complementary Indigenous knowledge systems that offer valuable insights for AI governance. Kaitiakitanga, rooted in Māori culture, embodies a profound sense of guardianship and responsibility for the well-being of the natural world and future generations (Beverland, 2022; Kawharu, 2000; Roberts et al., 1995). It emphasizes the interconnectedness of all living things and the importance of sustainable practices that ensure the health and vitality of ecosystems for generations to come (Jamieson, 2010; Jones, 2022). This principle has been successfully applied in various environmental management contexts.

For instance, in Aotearoa New Zealand, Kaitiakitanga has guided the collaborative restoration of the Whitefish River watershed, where Māori iwi (tribes) partnered with government agencies and local communities to improve water quality and restore the health of the ecosystem (Bohn & Kershner, 2002; Kiffney et al., 2018). This involved combining traditional Māori knowledge of the watershed with scientific data to develop sustainable management practices that respect the cultural significance of the river (AMC Engineers, 2015). Kaitiakitanga also informs Māori approaches to fisheries management, where sustainable fishing practices and marine conservation efforts are guided by the principle of rāhui, a traditional practice of temporary resource restriction to allow for replenishment (Matthews, 2018; Stanaway, 2016; van Halderen, 2020).

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Hózhó, a core principle in Navajo philosophy, emphasizes harmony, balance, beauty, and the interconnectedness of all beings (Haskie, 2002; Kahn-John & Koithan, 2015). It represents a holistic worldview that seeks to maintain equilibrium between physical, mental, spiritual, and social well-being (Willeto, 2012). Hózhó finds expression in various aspects of Navajo life, including community wellness programs, traditional healing practices, and cultural ceremonies (Kahn-John et al., 2021; Lewton & Bydone, 2000). The Navajo Nation's community health programs, for example, draw upon Hózhó to promote holistic well-being through initiatives that integrate traditional healing practices with modern medicine (Esteve, 2006). This includes incorporating traditional ceremonies, herbal remedies, and spiritual counseling into healthcare services (Nelson, 2020). The CIRCLE model, developed by the Navajo Nation, provides a culturally grounded framework for addressing family violence and promoting healthy relationships (Oetzel & Duran, 2004; Walters et al., 2020). This model emphasizes restoring balance and harmony within individuals, families, and communities, reflecting the core principles of Hózhó (Haskie, 2002).

Both Kaitiakitanga and Hózhó offer valuable perspectives on ethical AI development and governance, emphasizing the importance of community engagement, ecological consciousness, and long-term stewardship. By incorporating these principles into AI governance frameworks, we can promote the development of AI systems that are not only technologically advanced but also ethically sound and culturally sensitive.

2.6. Traditional Ecological Knowledge (TEK) and AI

Traditional Ecological Knowledge (TEK) represents the cumulative body of knowledge, practices, and beliefs concerning the relationships between living beings and their environments accumulated by Indigenous and local communities over generations (Dudgeon & Berkes, 2003; Hunter, 2014). TEK is characterized by its deep understanding of ecological processes, its emphasis on the interconnectedness of all living things, and its focus on long-term sustainability (Martin et al., 2010; Nelson & Shilling, 2018). In the context of AI, TEK offers valuable insights for developing and deploying AI systems that are ethically sound, environmentally responsible, and culturally appropriate (Perera et al., n.d.).

TEK can inform AI governance in several ways. First, it can help identify and mitigate potential biases in AI algorithms that may arise from a limited or Western-centric worldview. Second, in developing AI models for wildlife conservation, incorporating TEK can help ensure that the models accurately reflect the complex relationships between species and their environment, including Indigenous perspectives on animal behavior and habitat use. This can help avoid biases arising from relying solely on Western scientific data, which may not fully capture the nuances of Indigenous ecological knowledge (Duarte et al., 2019; Lauer & Aswani, 2009; van Eijck & Roth, 2007).

In the context of AI-powered resource management, TEK can challenge assumptions about optimal resource allocation and utilization (Huntington, 2000). For instance, TEK may emphasize the importance of preserving certain areas for cultural or spiritual reasons, even if they do not appear to have immediate economic value (Dudgeon & Berkes, 2003; Nelson & Shilling, 2018; Tsuji & Ho, 2002). By incorporating TEK into AI algorithms for resource management, we can ensure that these models consider a broader range of values and priorities, leading to more sustainable and equitable outcomes.

Furthermore, TEK can contribute to developing culturally appropriate AI governance frameworks that respect Indigenous rights, values, and knowledge systems (Ludwig & Macnaghten, 2020). By integrating TEK into the design and implementation of AI systems, we can ensure that these technologies are developed and deployed in a manner that is sensitive to Indigenous perspectives and promotes the well-being of Indigenous communities.

2.7. AI Governance Frameworks and Indigenous Participation

One of the key limitations of existing AI governance frameworks is the lack of Indigenous representation in their development and implementation (Omotubora & Basu, 2024). This exclusion

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can lead to AI governance structures that fail to consider Indigenous values, rights, and knowledge systems. To address this gap, it is essential to ensure the meaningful participation of Indigenous communities in AI governance processes. This can be achieved through various mechanisms.

The New Zealand government has established a Māori advisory board to provide guidance on AI policies affecting Māori communities (Kukutai et al., 2024; McGavin, 2023; Taiuru, 2020). This board ensures Māori perspectives are considered in AI governance decisions, and AI technologies are developed and deployed in a way that respects Māori rights and interests (Waitematā AI Governance Group, 2023). This has resulted in the development of culturally appropriate AI applications for environmental management and language revitalization (Mato, 2018).

In Canada, the First Nations Technology Council empowers Indigenous communities to participate in the digital economy and shape AI technologies (Budka, 2017; Matthews et al., 2021; McMahon, 2011). This has led to increased digital literacy and technological capacity within Indigenous communities, enabling them to leverage AI for economic development and cultural preservation (Holcombe & Kemp, 2019).

Another vital mechanism is mandatory consultation with Indigenous communities on AI-related policies. This ensures Indigenous voices are heard, and their concerns are addressed in developing AI governance frameworks. For instance, in Australia, the government has committed to consulting with Aboriginal and Torres Strait Islander communities on developing its national AI strategy (Browne et al., 2017; Hansen & O'Shane, 2016; Puszka et al., 2016). This commitment has resulted in the inclusion of Indigenous knowledge and values in the strategy, ensuring that AI benefits all Australians.

Furthermore, initiatives like the Indigenous Protocol and Artificial Intelligence (IPAI) working group demonstrate the power of Indigenous-led governance in AI. This international group, composed of Indigenous scholars and activists, is developing ethical guidelines and protocols for AI development that respect Indigenous rights and knowledge (Lewis et al., 2020). Their work has influenced AI policy discussions at the United Nations and other international forums, highlighting the importance of Indigenous leadership in shaping the future of AI (Garcia, 2022).

2.8. International Collaboration for Indigenous Inclusion in AI Governance

International collaboration is key to promoting Indigenous perspectives in AI governance. Organizations like UNESCO and the United Nations recognize the importance of Indigenous knowledge and are working to ensure Indigenous participation in AI policymaking (Hewitt, 2021). UNESCO's report on Indigenous data sovereignty emphasizes Indigenous control over their data, while the UN Declaration on the Rights of Indigenous Peoples provides a framework for protecting Indigenous rights in AI development (Hu et al., 2019; Régis et al., 2023).

The Global Indigenous Data Alliance (GIDA) exemplifies successful international collaboration. It brings together Indigenous organizations, researchers, and policymakers worldwide to advocate for Indigenous data sovereignty (Austin et al., 2021; Lovett et al., 2019). GIDA has been instrumental in promoting the CARE Principles for Indigenous Data Governance, which provide a framework for ethical data management that respects Indigenous rights (Oguamanam, 2020).

The International Council for Science (ICSU) program on "Indigenous and Local Knowledge Systems and Climate Change" fosters collaboration between Indigenous knowledge holders and scientists (Atkin et al., 1998; Ernster, 1984; Harrison, 2018). This program highlights the value of integrating Indigenous knowledge with scientific data for effective and sustainable solutions. International research projects also demonstrate the successful incorporation of Indigenous perspectives. The "AI for Social Good" initiative, led by the University of British Columbia with Indigenous communities in Canada, develops AI applications for environmental monitoring, language revitalization, and cultural heritage preservation that respect Indigenous knowledge (Dodhia, 2024; Oluwasanmi, 2020).

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These examples demonstrate the potential of international collaboration to promote Indigenous inclusion in AI governance, ensuring AI benefits all humanity while respecting diverse cultures and knowledge systems.

3. Māori Kaitiakitanga and AI Governance

3.1. Applications of Kaitiakitanga in Environmental Management

Kaitiakitanga, a core principle in Māori culture, emphasizes guardianship, responsibility, and the interconnectedness of all living things. It has influenced legislation such as the Te Urewera Act 2014, which recognizes Te Urewera, a region of land, as a legal entity with intrinsic rights, reflecting the interconnectedness of humans and the natural world (Coombes, 2020; Exton, 2017; Puketapu-Dentice, 2018, 2019; Te Urewera, 2018). By recognizing the rights of natural entities, Kaitiakitanga can inform the development of AI systems that respect ecological limits and prioritize the long-term health of ecosystems.

Another key application lies in resource allocation and utilization. Kaitiakitanga challenges conventional economic models that prioritize short-term gains over long-term sustainability. It emphasizes the importance of considering the interconnectedness of ecosystems and the potential impacts of resource extraction on future generations. By prioritizing long-term sustainability and incorporating Māori perspectives, initiatives like the National Policy Statement for Freshwater Management have led to improved water quality and the protection of culturally significant waterways (Ruckstuhl, 2022; Whaanga & Wehi, 2015).

Kaitiakitanga has played a crucial role in land-based conservation efforts, with Māori iwi implementing frameworks that incorporate traditional ecological knowledge to restore biodiversity (Arnold, 2024; Harcourt et al., 2022; Kahui & Richards, 2014; McAllister et al., 2023). This approach can inform the development of AI systems for conservation, enabling more effective monitoring of ecosystems and prediction of environmental changes while aligning with Indigenous values.

These examples demonstrate the diverse applications of Kaitiakitanga in promoting environmental sustainability and resource management. By drawing upon these experiences and integrating Kaitiakitanga principles into AI governance frameworks, we can promote the development of AI systems that respect the interconnectedness of humans and the natural world, prioritize long-term sustainability, and contribute to a more just and equitable technological future. These diverse applications of Kaitiakitanga offer valuable insights for developing AI governance frameworks that prioritize sustainability, intergenerational equity, and respect for the interconnectedness of humans and the natural world.

3.2. Kaitiakitanga and AI Governance Frameworks

Kaitiakitanga provides a robust ethical framework for environmental management, emphasizing collective guardianship, responsibility, and the interconnectedness of all living things (Aithal, 2023; Goralski & Tan, 2020; Khakurel et al., 2018; Khogali & Mekid, 2023). Its principles offer valuable guidance for developing AI governance frameworks that prioritize long-term well-being, sustainability, and respect for both present and future generations.

A key implication of Kaitiakitanga for AI governance is the focus on interconnectedness and holistic thinking. It recognizes that actions in one area can have far-reaching consequences for others, highlighting the need to consider the broader social, economic, and environmental impacts of AI development and deployment. By incorporating Kaitiakitanga principles into AI governance frameworks, we can promote AI systems that consider these interconnectedness and avoid unintended consequences (Connolly et al., 2024; Reid et al., n.d.; Wikitera, 2024).

For example, Kaitiakitanga can inform the development of AI systems for resource management. By considering the interconnectedness of ecosystems, AI algorithms can be designed to optimize resource allocation while minimizing negative environmental impacts (Challoumis, 2024; Kalusivalingam et al., 2020). This could involve incorporating traditional ecological knowledge into

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AI models to ensure they reflect the complex relationships between humans and the natural world, such as incorporating Māori knowledge of mauri (life force) into AI models for water management. This ensures that these models consider not only the physical and chemical properties of water but also its cultural and spiritual significance (Rangiwananga, 2020).

Furthermore, Kaitiakitanga emphasizes the importance of respecting and incorporating Indigenous knowledge and values in AI governance (Moewaka Barnes et al., 2021). This involves recognizing the value of traditional ecological knowledge and integrating it with scientific data to develop more effective and sustainable solutions. For instance, in developing AI systems for conservation, incorporating Indigenous perspectives on land management and resource stewardship can lead to more holistic and culturally appropriate solutions.

Kaitiakitanga can also guide the inclusion of Indigenous communities in AI governance processes. This could involve establishing Indigenous advisory boards, mandating consultation with Indigenous communities on AI-related policies, and including Indigenous representatives in AI governance bodies. By actively involving Indigenous communities in shaping the future of AI, we can ensure that AI technologies are developed and deployed in a way that respects Indigenous rights and interests (Palmer et al., 2023; Ruckstuhl et al., 2019).

In addition to these strategies, Kaitiakitanga can inform the development of new AI governance models that prioritize long-term sustainability and intergenerational equity. This could involve incorporating environmental impact assessments into every stage of the AI development lifecycle and promoting the use of AI for conservation and ecological restoration. By embedding Kaitiakitanga values into the core of AI governance, we can ensure that AI technologies are developed and deployed in a way that benefits both present and future generations.

4. Navajo Hózhó and AI Governance

4.1. Applications of Hózhó in Navajo Community Wellness Programs

Hózhó, a core principle in Navajo philosophy, emphasizes harmony, balance, beauty, and the interconnectedness of all beings. It represents a holistic worldview that seeks to maintain equilibrium between physical, mental, spiritual, and social well-being (Limb & Hodge, 2008). This principle finds expression in various aspects of Navajo life, including community wellness programs, where it guides the development of culturally grounded initiatives that promote health and healing.

One example is the Navajo Nation's Diabetes Prevention and Control Program, which incorporates Hózhó principles to address the disproportionately high rates of diabetes among Navajo people (Broussard et al., 1995; Satterfield, 2016). This program integrates traditional Navajo practices, such as storytelling and ceremonies, with modern health education and support services (The Diabetes Prevention Program Research Group, 2013). By recognizing the interconnectedness of mind, body, and spirit, the program promotes healthy lifestyles and empowers individuals to take control of their health.

Another application of Hózhó is in the Navajo Nation's Traditional Agricultural Outreach Program, which promotes food sovereignty and healthy eating habits by revitalizing traditional Navajo farming practices. This program supports Navajo farmers in growing traditional crops, such as corn, beans, and squash, using sustainable and culturally appropriate methods (McCaleb, 2024; Nabhan, 2016; Raymond & Falk, 2018). By fostering a connection to the land and traditional foodways, the program promotes physical health, strengthens cultural identity, and contributes to community well-being (Powell, 2018).

Hózhó also informs the Navajo Nation's efforts to address mental health challenges, particularly historical trauma and intergenerational grief stemming from colonization and forced relocation. Culturally-based healing programs incorporate traditional practices, such as storytelling, singing, and sand painting, to promote emotional healing and resilience (Griffin-Pierce, 1995; Salm—n, 2012; Tafoya, 2014). These programs recognize the interconnectedness of mental, emotional, and spiritual well-being, offering a holistic approach to healing that aligns with Hózhó values.

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These examples illustrate the diverse applications of Hózhó in promoting community wellness and addressing health challenges. By integrating this Indigenous knowledge system into healthcare and community development programs, the Navajo Nation has made significant strides in promoting holistic well-being and strengthening cultural identity.

4.2. Hózhó and AI Governance Frameworks

The Navajo principle of Hózhó, with its emphasis on harmony, balance, interconnectedness, and holistic well-being, offers valuable insights for developing AI governance frameworks that are ethically sound, culturally sensitive, and aligned with the values of community and environmental well-being (Bengio et al., 2023; Williams & Shipley, 2021).

One key implication of Hózhó for AI governance is the focus on relationality and interconnectedness. Hózhó recognizes that all things are interconnected and that actions taken in one area can have far-reaching consequences for others. This perspective is crucial in AI governance, where decisions about data collection, algorithm design, and AI deployment can have significant social, economic, and environmental impacts. By incorporating Hózhó principles into AI governance frameworks, we can promote the development of AI systems that consider these interconnectedness and strive to create positive outcomes for all stakeholders, including Indigenous communities and the natural world.

Hózhó also emphasizes the importance of balance and harmony. In Navajo philosophy, Hózhó represents a state of equilibrium and well-being that encompasses physical, mental, spiritual, and social dimensions. This concept can inform AI governance by encouraging the development of AI systems that promote balance and harmony within society (LCJ, 2023). This could involve designing AI algorithms that avoid bias and discrimination, ensuring that AI technologies are used to promote social justice and equity, and considering the potential impacts of AI on human well-being and the environment.

Furthermore, Hózhó highlights the importance of community engagement and collaboration. In Navajo culture, decisions are often made collectively, with input from various community members (Chataway, 1997; Iseke & Moore, 2011; Searight & Gafford, 2005). This approach can inform AI governance by promoting the inclusion of diverse voices in AI development and deployment processes. This could involve establishing community advisory boards, conducting consultations with Indigenous communities on AI-related policies, and ensuring that Indigenous representatives are involved in decision-making processes related to AI (Ben Dhaou et al., 2024).

Moreover, Hózhó can guide the development of AI systems that respect Indigenous cultural values and knowledge systems. By incorporating Indigenous perspectives into the design and development of AI algorithms, we can mitigate the potential for AI to perpetuate cultural biases and discrimination. This could involve collaborating with Indigenous knowledge holders to identify and address potential biases in AI models and ensuring that AI systems are developed and deployed in a culturally sensitive and appropriate manner. This aligns with Hózhó's emphasis on balance and harmony, promoting the respectful integration of AI technologies into Indigenous communities.

5. A Comparative Analysis: Weaving Indigenous Perspectives Together

Māori Kaitiakitanga and Navajo Hózhó, while arising from distinct cultural contexts, share a common thread: a profound respect for the interconnectedness of all things and a commitment to long-term well-being. By analyzing their core principles and applications, we can identify key areas of convergence and divergence that offer valuable insights for developing holistic and culturally responsive AI governance frameworks.

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Table 1. Kaitiakitanga versus Hózhó.

Principle	*Māori Kaitiakitanga*	*Navajo Hózhó*
Focus	Guardianship and stewardship of the natural world	Harmony, balance, and interconnectedness of all things
Core Values	Guardianship, stewardship, reciprocity, collective responsibility	Harmony, balance, beauty, interconnectedness
Applications	Environmental management, resource allocation, community decision-making	Health initiatives, community development, cultural preservation
Relevance to AI Governance	Data sovereignty, ecological sustainability, intergenerational equity	Human well-being, environmental sustainability, ethical technology use

Points of Convergence:

Interconnectedness in AI Systems: Both Kaitiakitanga and Hózhó stress the interconnectedness of all things, prompting a shift away from siloed thinking in AI governance (Ashok et al., 2024; Andrade & Vasquez, 2024). This encourages the development of AI systems that consider the complex interplay between humans, the environment, and technology, fostering harmony and minimizing unintended consequences. For instance, AI algorithms for resource management could integrate ecological data with social and cultural considerations, ensuring equitable and sustainable outcomes.

Long-Term Vision for AI: Both traditions prioritize long-term well-being over short-term gains, challenging the often anthropocentric and short-sighted focus of existing AI governance frameworks (Causevic et al., 2024; Caudill et al., 2024). By incorporating these Indigenous perspectives, we can promote the development of AI that prioritizes sustainability and intergenerational equity. This could involve designing AI systems that consider the long-term impacts on future generations, ensuring that AI technologies contribute to a more just and equitable future for all.

Community-Driven AI Governance: Both traditions emphasize community engagement and collaboration in decision-making processes (Grant & Söderbergh, 2020; Li & Brar, 2022; Williams & Shipley, 2021). This shared value underscores the importance of including Indigenous communities in AI governance, ensuring that AI technologies are developed and deployed in a culturally appropriate and respectful manner. This could involve establishing Indigenous-led AI ethics committees, mandating consultation with Indigenous communities on AI policies, and supporting Indigenous-driven AI initiatives that address community-specific needs and priorities.

Points of Divergence:

Focus and Scope: While both traditions emphasize interconnectedness, their focus and scope differ. Kaitiakitanga is deeply rooted in environmental stewardship and the relationship between humans and the natural world. In contrast, Hózhó encompasses a broader notion of well-being that includes physical, mental, spiritual, and social dimensions. This difference is evident in how Hózhó has shaped the Navajo Nation's approach to health and wellness, which considers physical, mental, spiritual, and social well-being as interconnected aspects of a whole. This holistic perspective could inform AI applications in healthcare, ensuring they address not only physical ailments but also the social and cultural determinants of health.

Cultural Expression: The cultural expressions of Kaitiakitanga and Hózhó are distinct, reflecting the unique histories and traditions of Māori and Navajo communities. These diverse cultural expressions can enrich AI governance by providing a broader understanding of ethical values and

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practices from different Indigenous perspectives. For example, Hózhó's emphasis on balance and harmony could inform the development of AI systems that promote social justice and equity, while Kaitiakitanga's concept of whakapapa (genealogy), which emphasizes the interconnectedness of all living things through ancestral lineage, could inform AI development by promoting the consideration of historical and intergenerational impacts, ensuring that AI technologies do not perpetuate past injustices or harm future generations.

Implications for AI Governance:

This comparative analysis reveals that Kaitiakitanga and Hózhó offer complementary yet distinct perspectives that can enhance AI governance frameworks. By weaving these Indigenous perspectives together, we can create more holistic and culturally responsive approaches to AI development and deployment. This involves recognizing the interconnectedness of all things, prioritizing long-term well-being, and ensuring the active participation of Indigenous communities in AI governance processes. This could involve developing ethical guidelines for AI that incorporate both Kaitiakitanga and Hózhó principles, such as prioritizing long-term sustainability, ensuring community engagement in AI development, and recognizing the interconnectedness of human societies, natural ecosystems, and technological systems. Additionally, creating mechanisms for ongoing dialogue and collaboration between Indigenous communities and AI developers is crucial.

Moreover, Kaitiakitanga and Hózhó offer valuable tools for addressing specific challenges in AI governance. For instance, Kaitiakitanga's emphasis on collective ownership and responsibility can inform the development of data governance frameworks that prioritize Indigenous data sovereignty. Hózhó's focus on balance and harmony can guide the design of AI algorithms that avoid bias and discrimination. Both traditions can contribute to a more ethical and culturally sensitive approach to AI deployment, ensuring that AI technologies are used in a way that respects Indigenous rights and values.

While Kaitiakitanga and Hózhó offer valuable insights, potential tensions may arise when integrating them with existing AI governance frameworks. For instance, the emphasis on collective ownership in Kaitiakitanga may need careful consideration alongside individual rights and data privacy concerns. Similarly, the concept of utu (reciprocity) in Kaitiakitanga, which suggests that any harm to the environment should be met with reciprocal action to restore balance, may present challenges in the context of AI development, where unintended consequences can be difficult to predict or fully mitigate (Barnett, 2021; Kawharu, 2000). Navigating these tensions requires open dialogue and collaboration between Indigenous communities, AI developers, and policymakers to develop culturally appropriate solutions that respect both individual and collective rights. Additionally, it necessitates a critical examination of Western ethical principles and legal frameworks, recognizing that they may not always align with Indigenous values and worldviews.

6. Recommendations and Implementation Strategies

Integrating Indigenous knowledge systems like Kaitiakitanga and Hózhó into AI governance requires a multifaceted approach that considers the intricate tapestry of AI's technical and ethical dimensions. This necessitates creating frameworks that guide decision-making throughout the AI lifecycle, from the initial stages of data collection and algorithm design to the deployment and ongoing monitoring of AI systems. We propose a framework that draws upon key principles from Kaitiakitanga and Hózhó to foster the development of AI that is not only innovative but also responsible, ethical, and culturally sensitive.

Effective data governance forms the bedrock of ethical AI development, particularly when Indigenous communities and knowledge are involved. Establishing Indigenous-led data governance bodies is paramount. These bodies, empowered to oversee the collection, storage, and use of Indigenous data, would play a critical role in crafting culturally appropriate data governance protocols. These protocols would prioritize Indigenous data sovereignty, ensuring that data is collected and utilized in a manner that respects Indigenous rights, values, and traditional practices.

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This might involve implementing robust data anonymization and encryption techniques, drawing upon cutting-edge privacy-enhancing technologies like differential privacy and federated learning to safeguard sensitive Indigenous information (Aouedi et al., 2024; Paul & Mandal, 2024). Drawing inspiration from the work of Indigenous AI leaders like Jason Edward Lewis, Angie Abdilla, and Te Hiku Media, these protocols should include provisions for data sharing agreements that respect Indigenous intellectual property rights, community consent mechanisms that prioritize collective decision-making, and the establishment of data trusts that empower Indigenous communities to manage and protect their data.

The design of AI algorithms should be guided by Indigenous knowledge and values to mitigate bias, promote fairness, and ensure transparency and accountability. Collaborating with Indigenous knowledge holders can illuminate potential biases embedded within existing AI models and inform the development of decolonizing algorithms. AI models should be designed with a deep understanding of the interconnectedness of human societies, natural ecosystems, and technological systems, promoting holistic and sustainable outcomes (Bibri et al., 2024; Nishant et al., 2020). This could entail embedding Indigenous perspectives on environmental sustainability, social justice, and intergenerational equity into the very fabric of AI algorithms (Golub et al., 2013; Mitrofanenko, 2016). To ensure cultural appropriateness and prevent the perpetuation of harmful stereotypes, Indigenous communities should be actively involved in evaluating and testing AI algorithms. This could involve creating culturally specific datasets for training and testing AI models and establishing community-led review boards to assess the ethical implications of AI algorithms.

Prior to deploying AI systems, rigorous ethical impact assessments are crucial. These assessments, conducted in collaboration with Indigenous communities, should incorporate Indigenous knowledge and values to ensure that AI technologies are deployed in a culturally sensitive and responsible manner. This might involve developing culturally specific ethical guidelines that address the unique concerns and values of Indigenous communities. For instance, an Indigenous AI Ethics Council, composed of Indigenous knowledge holders, AI ethicists, and legal experts, could be established to provide guidance on the ethical development and deployment of AI systems that impact Indigenous communities. This council could develop culturally specific ethical guidelines, review AI projects for potential impacts on Indigenous rights and interests, and provide recommendations for mitigating harm. Additionally, community-led monitoring and evaluation frameworks are essential for tracking the long-term impacts of AI on Indigenous communities and ensuring alignment with Indigenous values. This could involve creating community-based monitoring programs, developing culturally relevant indicators for measuring AI impacts, and establishing robust feedback mechanisms for Indigenous communities to voice their experiences and concerns. In cases where AI systems inadvertently cause harm to Indigenous communities, mechanisms for redress and accountability should be readily available. This could involve establishing Indigenous-led tribunals or dispute resolution processes that draw upon Indigenous legal traditions and prioritize restorative justice.

Investing in capacity building is essential for empowering Indigenous communities to become active participants in AI governance. This involves supporting educational and training programs tailored to the specific needs and interests of Indigenous communities, increasing their understanding of AI and their ability to engage in AI governance processes. Furthermore, supporting the development of Indigenous-led AI initiatives can foster self-determination and technological empowerment. This could involve providing funding, resources, and mentorship to Indigenous entrepreneurs and innovators developing AI solutions for their communities. Fostering collaboration between Indigenous knowledge holders, AI developers, and policymakers is vital for weaving Indigenous perspectives into the fabric of AI governance frameworks. This could involve creating platforms for knowledge sharing and dialogue, establishing joint research initiatives, and developing collaborative governance models that recognize and respect Indigenous knowledge systems.

Furthermore, AI models should be designed to consider the interconnectedness of human societies, natural ecosystems, and technological systems, promoting holistic and sustainable

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outcomes. This could involve incorporating Indigenous perspectives on environmental sustainability, social justice, and intergenerational equity into the design of AI algorithms. To mitigate the environmental impact of AI, particularly the energy consumption of data centers, we recommend promoting the development of sustainable AI infrastructure, such as data centers powered by renewable energy sources and the use of energy-efficient AI algorithms. Additionally, to counteract the potential for LLMs to create language hegemonies, we recommend supporting the revitalization and preservation of Indigenous languages through AI-powered language learning tools and the development of culturally diverse language models.

By embracing these recommendations and grounding AI governance in Indigenous knowledge systems, we can foster the development of AI technologies that are not only ethically sound and culturally sensitive but also contribute to a more just and sustainable future for all. This approach requires a commitment to ongoing dialogue, collaboration, and mutual respect between Indigenous communities, AI developers, and policymakers to navigate the complexities of integrating Indigenous knowledge into AI governance and ensure that AI technologies benefit all members of society.

7. Discussion and Conclusions

This paper has explored the potential of Indigenous knowledge systems, specifically Māori Kaitiakitanga and Navajo Hózhó, to enhance AI governance frameworks. By examining the core principles and applications of these traditions, we have demonstrated their relevance to addressing the ethical challenges posed by AI and promoting a more inclusive and sustainable technological future.

Our analysis reveals that Kaitiakitanga and Hózhó offer valuable insights for shaping AI governance in several key ways. First, they emphasize the interconnectedness of all things, challenging the anthropocentric and often siloed approaches prevalent in existing AI governance frameworks. This holistic perspective encourages the development of AI systems that consider the broader impacts of AI on human societies, natural ecosystems, and future generations. Second, these Indigenous traditions prioritize long-term well-being over short-term gains, promoting a more sustainable and responsible approach to AI development and deployment. This challenges the prevailing focus on rapid technological advancement and economic growth, encouraging a more mindful and ethical approach to AI innovation.

Third, Kaitiakitanga and Hózhó emphasize the importance of community engagement and collaboration in decision-making processes. This highlights the need for Indigenous communities to be actively involved in shaping AI policies and development processes, ensuring that AI technologies are culturally appropriate, respect Indigenous rights and interests, and contribute to the well-being of Indigenous communities.

By integrating these Indigenous perspectives into AI governance frameworks, we can foster the development of AI technologies that are not only ethically sound and culturally sensitive but also contribute to a more just and sustainable future for all. This requires a commitment to ongoing dialogue, collaboration, and mutual respect between Indigenous communities, AI developers, and policymakers to navigate the complexities of integrating Indigenous knowledge into AI governance and ensure that AI technologies benefit all members of society.

Further research could explore the applications of other Indigenous knowledge systems to AI governance, enriching the global conversation on AI ethics and promoting the inclusion of diverse cultural perspectives in shaping the future of technology. Additionally, investigating the potential of AI to support Indigenous communities in revitalizing their languages, protecting their cultural heritage, and addressing pressing social and environmental challenges could further illuminate the mutually beneficial relationship between Indigenous knowledge and AI.

 doi:10.20944/preprints202410.2112.v3

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