Indigenous Knowledge, Artificial Intelligence, Green Technology and Sustainable Development

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INDIGENOUS KNOWLEDGE, ARTIFICIAL INTELLIGENCE, GREEN TECHNOLOGY AND SUSTAINABLE DEVELOPMENT

PREFACE

The book Indigenous Knowledge, Artificial Intelligence, Green Technology and Sustainable Development brings together important perspectives on traditional knowledge, technological innovation, environmental sustainability, and inclusive development.

Indigenous knowledge represents generations of experience, wisdom, and practices developed through a close relationship with nature and communities. It offers valuable insights into areas such as biodiversity, agriculture, natural resource management, traditional practices, climate adaptation, and sustainable living.

At the same time, Artificial Intelligence (AI) and Green Technology are creating new opportunities to address complex social, economic, and environmental challenges. Responsible integration of traditional knowledge with modern science and technology can contribute to innovative solutions while respecting cultural values, community rights, and environmental responsibility.

This book provides a multidisciplinary platform for researchers, academicians, students, Indigenous knowledge holders, technology professionals, policymakers, and development practitioners to share ideas, research findings, case studies, and innovative approaches.

The broader objective of this publication is to encourage knowledge exchange, responsible innovation, cultural preservation, environmental protection, and sustainable development for present and future generations.

We sincerely thank all authors, contributors, reviewers, researchers, and supporting institutions whose valuable efforts have made this publication possible.

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INTRODUCTION

Indigenous Knowledge, Artificial Intelligence, Green Technology and Sustainable Development

The book Indigenous Knowledge, Artificial Intelligence, Green Technology and Sustainable Development is an initiative of the World Council of Indigenous Games (WIG), an international platform dedicated to promoting and developing Indigenous Games, traditional knowledge, cultural heritage, youth engagement, and sustainable community development.

Indigenous Knowledge represents generations of wisdom, experience, skills, traditions, and practices developed through a close relationship between communities and nature. It provides valuable insights into biodiversity conservation, agriculture, natural resource management, climate adaptation, cultural preservation, and sustainable living.

At the same time, Artificial Intelligence (AI) and Green Technology are creating new opportunities to address contemporary social, technological, and environmental challenges. Responsible integration of Indigenous Knowledge with modern science and technology can support innovation while respecting cultural values, community participation, and environmental responsibility.

The book explores the interconnected themes of Indigenous Knowledge, Artificial Intelligence, Green Technology, and Sustainable Development, bringing together research, academic perspectives, case studies, and innovative ideas from different disciplines.

Through this publication, World Council of Indigenous Games (WIG) seeks to encourage knowledge exchange between traditional wisdom and modern innovation, while supporting education, research, cultural preservation, environmental sustainability, and inclusive development. WIG's stated mission includes promoting and developing Indigenous Games worldwide and creating knowledge-sharing opportunities.

This book is intended for researchers, academicians, students, Indigenous communities, policymakers, technology professionals, environmental practitioners, and development organisations interested in building a sustainable and responsible future.

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YOUTH LEADERSHIP AND COMMUNITY DEVELOPMENT

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ABSTRACT: Youth leadership is not simply about leading a group or holding a title; it is about motivating others, taking responsibility, and creating meaningful change within society. Young people bring fresh perspectives, innovative thinking, and enthusiasm, making them key drivers of community growth. When they are encouraged to participate in decision-making and social initiatives, they become capable of finding practical solutions to the challenges faced by their communities. One creative way to strengthen community development is by establishing **"Youth Innovation Circles."** These are collaborative groups where young individuals work alongside local residents to identify community needs and design solutions for issues such as environmental protection, digital education, public health, waste management, and learning support. By focusing on local participation and available resources, these groups encourage communities to become more independent and actively involved in improving their surroundings. Technology can further enhance these efforts by helping youth leaders coordinate volunteers, track project outcomes, and share successful initiatives with a wider audience. Through these experiences, young people also develop valuable skills such as communication, collaboration, critical thinking, adaptability, and ethical leadership. When communities recognize young people as partners in development rather than merely beneficiaries, they create an environment where innovation and cooperation flourish. Supporting youth leadership today lays the groundwork for stronger communities, sustainable development, and a more inclusive future for everyone.

KEYWORDS: ***Youth Leadership, Community Development, Youth Empowerment, Social Innovation, Sustainable Development***

INTRODUCTION

The progress of any community depends largely on the people who are willing to step forward and make a difference. Among them, young people hold a unique position because they bring enthusiasm, fresh ideas, and the confidence to challenge conventional ways of thinking. In recent years, the role of youth has expanded beyond preparing for future responsibilities. They are now recognized as active contributors who can influence social development through innovation, collaboration, and meaningful participation. As communities continue to face complex issues such as environmental concerns, educational disparities, unemployment, and public health challenges, the involvement of young leaders has become increasingly essential. Youth leadership is not defined by titles or positions of authority alone. It is reflected in the ability to inspire others, take initiative, and work collectively toward a shared purpose. Young leaders encourage participation, promote positive values, and motivate people to contribute to the well-being of their communities. By engaging in social activities and community projects, they gain practical experience, improve their decision-making abilities, and develop important life skills. At the same time, their efforts create long-term benefits by encouraging social responsibility and strengthening community relationships. Meaningful community development is possible only when local people actively participate in shaping their own future. While government agencies and non-governmental organizations play important roles, sustainable progress is achieved when community members themselves become part of the solution. Young people are particularly well-equipped for this role because they combine creativity with technological knowledge and a willingness to explore innovative approaches. Their active participation promotes teamwork, encourages volunteerism, and ensures that development initiatives reflect the genuine needs and aspirations of the community. One promising idea for increasing youth participation is the formation of “Youth Innovation Circles”. These groups bring together young volunteers and local residents to

identify community issues and develop practical, locally relevant solutions. Whether the focus is environmental conservation, digital literacy, health awareness, educational support, or waste management, these collaborative groups encourage people to work together by using available resources and local knowledge. Rather than depending entirely on external support, this approach empowers communities to solve their own problems while providing young people with valuable opportunities to strengthen their leadership abilities through real-world experience. The effective use of technology further enhances these initiatives by m0aking communication, coordination, and project monitoring more efficient. Digital platforms enable youth leaders to organize volunteers, exchange ideas, showcase successful practices, and measure the impact of community activities. These tools not only increase transparency but also inspire similar initiatives in other communities, creating a wider network of social learning and cooperation. Empowering young people to take leadership roles is an investment in the future of society. When communities encourage youth to become active partners in development instead of limiting them to passive participation, they create an environment where innovation, responsibility, and collaboration can flourish. Such an approach strengthens communities, supports sustainable development, and prepares future generations to face emerging social challenges with confidence, compassion, and a shared commitment to collective progress.

SCOPE OF THE STUDY

This study focuses on understanding how youth leadership can influence community development by encouraging active participation, innovative thinking, and shared responsibility. It explores the growing role of young people as agents of positive social change who contribute not only through leadership positions but also through their ideas, commitment, and involvement in addressing local challenges. The study examines how youth participation can strengthen community relationships, encourage collective action, and support sustainable development that reflects the needs and aspirations of local people. An important dimension of this study is the proposed concept of Youth Innovation Circles, which serves as a collaborative platform where young people and community members work together to identify local issues and develop practical, community-driven solutions. The study considers how this approach can be applied to areas such as environmental protection, digital inclusion, public health awareness, educational assistance, and waste management. By promoting cooperation and the effective use of local resources, these initiatives aim to encourage self-reliant communities while nurturing leadership qualities among young participants. The study also recognizes the increasing role of digital technology in strengthening youth-led community initiatives. It explores how online platforms and digital tools can improve communication, organize volunteer activities, facilitate the exchange of ideas, and monitor the progress of community projects. These technologies have the potential to expand participation and improve the overall effectiveness of youth-driven development efforts. The study adopts a practical and future-oriented perspective by viewing youth leadership as a continuous journey of learning, collaboration, and community engagement. The insights generated through this study are expected to benefit educators, policymakers, youth organizations, and community development practitioners by offering innovative approaches to youth empowerment. Ultimately, the study seeks to demonstrate how empowering young people can build stronger, more inclusive, and resilient communities that are better prepared to meet future social and developmental challenges.

RESEARCH QUESTIONS

1. In what ways does youth leadership contribute to the overall development and well-being of local communities?
2. Which leadership skills and personal qualities help young people create meaningful and lasting social change?
3. How can Youth Innovation Circles encourage greater community participation and support collaborative solutions to local issues?
4. How does the use of digital technology improve the planning, implementation, and impact of youth-led community initiatives?

5. What effect does active involvement of young people have on social inclusion, community resilience, and shared responsibility?
6. What are the major opportunities and barriers experienced by young leaders while working on community development initiatives?
7. How can partnerships among youth, local communities, educational institutions, and social organizations contribute to sustainable community growth?
8. How can youth-led leadership initiatives encourage long-term civic participation and foster sustainable community progress?

Objectives of the study

1. To explore the contribution of youth leadership to the sustainable growth and development of communities.
2. To identify the key leadership skills and attributes that enable young people to bring about positive social transformation.
3. To assess the potential of Youth Innovation Circles as an innovative approach to solving community problems through collective participation.
4. To examine how digital technologies can enhance the effectiveness of youth-led community development activities.
5. To understand the impact of youth participation on strengthening community engagement, inclusiveness, and collective responsibility.
6. To identify the opportunities and challenges encountered by young leaders while implementing community-based initiatives.
7. To evaluate the role of collaboration among youth, community members, educational institutions, and development organizations in achieving sustainable community outcomes.
8. To develop practical recommendations that strengthen youth leadership and encourage inclusive, resilient, and sustainable community development.

REVIEW OF LITERATURE

1. Som Nepali and Rajesh Tamang (2026) examined how adolescents in Nepal participate in community development and social change through a qualitative research approach. The study found that youth leadership goes beyond formal positions and includes peer mentoring, project coordination, and community advocacy. It highlighted that experiential learning and mentorship help young people develop leadership skills, teamwork, decision-making ability, and civic responsibility. Although barriers such as gender inequality, socio-economic challenges, and cultural norms restricted participation, inclusive support strategies encouraged greater involvement among marginalized youth. The authors concluded that providing structured opportunities for leadership and community engagement empowers adolescents and contributes to both personal growth and stronger, more resilient communities.
2. Winston Kenneth Agcarao Balauro (2026) reviewed existing studies on youth leadership competencies and community involvement within 4-H Clubs to understand their role in youth development. The review found that structured youth organizations help develop leadership skills, strengthen civic participation, and encourage active involvement in community and agricultural activities. It also highlighted that the Positive Youth Development (PYD) framework effectively supports the growth of confidence, character, competence, and social responsibility among young people. However, the study identified gaps in localized research and noted that limited resources and institutional support can reduce the effectiveness of youth programmes. The author concluded that strengthening leadership training, mentorship, and policy support is essential for empowering youth and enhancing sustainable community development.
3. Desika Putri Mardiani et al. (2025) explored how youth leadership contributes to mobilizing rural communities for sustainable development in Indonesia through a phenomenological research approach.

The study revealed that young leaders play an important role in fostering community participation, strengthening social unity, and encouraging local self-reliance. It also highlighted that youth-led initiatives enhance community resilience and support the achievement of the Sustainable Development Goals (SDGs). Furthermore, the findings emphasized that collaboration, innovation, and grassroots leadership are essential for addressing socio-economic issues effectively. The authors concluded that empowering young people as community leaders is a sustainable and practical approach to promoting inclusive rural development.

4. Augustine Okorodudu (2025) proposed a Community-Based Integrative Model (CBIM) that combines civic literacy, leadership development, and ethical media communication to strengthen youth engagement. The study emphasized that these three areas should be integrated rather than addressed through separate programs. It highlighted that collaboration among educational institutions, community organizations, and media platforms can enhance young people's leadership skills, civic participation, and responsible communication. The findings suggested that a coordinated community-based approach is more effective in preparing youth to address misinformation and participate actively in democratic processes. The author concluded that integrating civic education, ethical communication, and leadership training provides a sustainable framework for empowering youth and strengthening community development.
5. Shereé M. Bielecki (2024) explored the use of Photovoice as an innovative approach to strengthen youth engagement and leadership development within communities. The study highlighted that Photovoice provides young people with a meaningful platform to express their ideas, concerns, and aspirations while actively participating in community initiatives. It emphasized that this participatory method enhances leadership skills, encourages civic involvement, and supports social justice by amplifying youth perspectives. The research also discussed the ethical and practical considerations involved in implementing Photovoice projects in educational and community settings. The author concluded that integrating Photovoice into youth development programmes can effectively empower young people, strengthen community engagement, and foster future leaders.

RESEARCH GAP

A considerable amount of research has examined the relationship between youth leadership and community development, emphasizing the significance of civic engagement, youth empowerment, mentorship, digital participation, and social innovation in promoting positive social outcomes. While these studies have enriched the understanding of youth leadership, they have largely explored these dimensions individually instead of viewing them as interconnected components of a unified community development approach. In addition, much of the existing literature has been conducted within specific environments, such as educational institutions, rural communities, and organized youth programmes. Although these studies offer valuable insights, there is still a lack of flexible and comprehensive models that can be effectively applied across different community settings. The literature also pays limited attention to how young people can work alongside local communities to identify challenges, develop innovative solutions, and sustain development efforts through continuous participation and the effective use of technology. Moreover, only a few studies have proposed practical frameworks that integrate youth leadership, community partnership, digital engagement, and social innovation into a single model for sustainable development. This highlights the need for a holistic approach that empowers young people to become active leaders while strengthening collaboration, innovation, and long-term community development.

CONCLUSION

Youth leadership plays a vital role in building stronger, more inclusive, and sustainable communities. In a rapidly changing world marked by social, economic, and environmental challenges, young people possess the energy, creativity, and determination needed to bring about meaningful change. Rather than being

viewed only as future leaders, they should be recognized as active contributors who can influence community development through innovation, collaboration, and responsible action.

This study demonstrates that lasting community development is possible when young people are encouraged to participate in identifying local needs and developing practical solutions in partnership with community members. The proposed concept of Youth Innovation Circles offers a collaborative platform that promotes creativity, shared responsibility, and collective decision-making. By combining leadership development with technology, social innovation, and active community participation, this approach provides a practical framework for achieving sustainable and inclusive development.

The study also highlights that effective youth leadership depends on a supportive environment created through the combined efforts of educational institutions, policymakers, community organizations, and local stakeholders. Opportunities such as mentorship, experiential learning, digital engagement, and community service help young people strengthen their leadership abilities, build confidence, and develop the skills required to address real-world challenges.

In conclusion, empowering youth is essential for the long-term progress of both communities and society. When young people are trusted, supported, and encouraged to lead, they become powerful drivers of positive social transformation. Strengthening partnerships, promoting innovation, and creating meaningful opportunities for youth participation can enhance community resilience and foster sustainable development. Ultimately, the future of community development depends not only on policies and resources but also on the vision, commitment, and leadership potential of empowered young people who are prepared to create lasting and meaningful change.

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THE ROLE OF THE WELLNESS AND SPA CONSULTANT IN BULGARIA IN PROMOTING HEALTH, WELL-BEING AND SUSTAINABLE DEVELOPMENT

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Abstract: The present study analyzes the emergence, development, and establishment of the academic specialization *"Wellness and SPA Consultant"* in Bulgaria and the role of professional education in promoting health, well-being, and sustainable development within the contemporary wellness and SPA sector. The study examines the institutional prerequisites for the introduction and development of the specialization, its academic provision, interest among prospective students, opportunities for professional realization, and interaction with the tourism, hospitality, and wellness and SPA sectors. The main professional competencies of the Wellness and SPA Consultant and their significance for the provision of integrated services aimed at promoting the physical and psychosocial well-being of individuals are analyzed. Based on data and trends up to 2025, key opportunities and challenges for the development of the profession in Bulgaria are identified. The study considers the profession of "*Wellness and SPA Consultant" as a potential factor in the development of a sustainable, competitive, and human well-being-oriented wellness and SPA sector,* in accordance with contemporary concepts of health, quality of life, and sustainable development.

Keywords: *Wellness and SPA Consultant, health, well-being, sustainable development, professional education, professional realization in Bulgaria*

Introduction

Over the past two decades, wellness tourism and its associated spa services have emerged as a significant segment of the contemporary tourism sector. In the academic literature, wellness tourism is conceptualized as a distinct segment of health tourism, with a primary focus on health maintenance and enhancement, prevention, physical and psychological well-being, and quality of life. At an early stage in the development of the concept, Mueller and Lanz Kaufmann (2001) defined wellness tourism as an approach oriented towards prevention and proactive health management, emphasizing service quality, individualized care, and the provision of health-related information as essential determinants of its competitiveness. This conceptual foundation places the individual and their well-being at the centre of the wellness experience.

The contemporary evolution of wellness tourism demonstrates that the sector is progressively extending beyond the traditional perception of the spa as a space primarily dedicated to relaxation and recovery. Wellness services are increasingly associated with preventive strategies, physical activity, healthy lifestyles, stress management, psychosocial well-being, and personalized tourism experiences. Smith and Puczkó (2014) conceptualize health, wellness, and spa tourism as interconnected domains in which tourism experiences, health promotion, hospitality, and the pursuit of enhanced quality of life converge. Consequently, the development of the wellness sector entails not only an expansion of the tourism offer but also increasingly demanding requirements for the professional competencies of the human resources involved.

The economic dynamics of the sector further substantiate its global significance. Data from the Global Wellness Institute indicate that the global wellness economy reached USD 5.6 trillion in 2022, representing a 27% increase compared with 2020. During the 2020–2022 period, wellness tourism was among the fastest-recovering segments, with its global market reaching USD 650.7 billion**,** corresponding to an average annual growth rate of 36.2% in expenditures. Over the same period, the number of wellness trips increased by an average of 30.2% annually, exceeding the corresponding growth rates recorded for the overall tourism market in terms of both travel volume

and tourism expenditures. In 2022, approximately 819.4 million wellness trips were recorded, accounting for 7.8% of all tourism trips while generating 18.7% of total tourism expenditures. For the period 2022–2027, the Global Wellness Institute projects an average annual growth rate of 16.6% for wellness tourism, with the market expected to reach approximately USD 1.4 trillion by 2027 (Global Wellness Institute, 2023).

These indicators demonstrate that wellness tourism represents not merely an expanding tourism product but also a significant economic ecosystem in which health, human well-being, physical activity, tourism, services, and human capital development intersect. Within this context, there is a growing need for professionals capable of integrating knowledge from diverse fields and translating it into practice within wellness and spa environments.

From a destination-development perspective, wellness tourism is grounded in the integration of natural resources, cultural heritage, health and recreational opportunities, and specialized tourism services. Voigt and Pforr (2013) examine wellness tourism specifically within the destination context, emphasizing the resource base, consumer experience, well-being, and the need for integrated development of tourism offerings. This perspective is particularly relevant to Bulgaria, where wellness and spa tourism is supported by a combination of mineral waters, climatic resources, natural and cultural heritage, and well-established balneological traditions.

Within the Bulgarian context, the quality of wellness services is closely associated with the professional preparation of specialized personnel. Dimitrova (2019) examines quality standards for wellness services and the certified competencies of specialized personnel within Bulgarian niche tourism. Based on an expert survey among professionals working in Wellness, SPA, and Thalasso centres, the study establishes a direct relationship between professional competencies and service quality. The author emphasizes the importance of systematic quality standards and professional qualification for enhancing the quality and competitiveness of wellness provision. Particular attention is given to the interaction between the natural environment, innovative wellness services, and the formation of a culture of health and well-being. This multidimensional perspective is essential for understanding the professional role of the Wellness and Spa Consultant, whose preparation should enable the integration of diverse components of the wellness experience rather than being restricted to individual procedures or services (Dimitrova, 2019).

The relationship between academic education and the needs of the industry is of particular importance for the development of this professional profile. Dimitrova (2023) analyses educational policy, specialized personnel, innovation, and the development of the recreational industry in Bulgaria. The author identifies a shortage of specialized personnel in niche tourism and emphasizes the need to integrate scientific knowledge into Wellness & SPA practices. The study also examines emerging Wellness & SPA educational programmes at the National Sports Academy “Vasil Levski”, highlighting the need for closer alignment between higher education, professional competencies, and the actual requirements of the sector (Dimitrova, 2023).

An important component of contemporary wellness is the integration of natural and cultural heritage into innovative wellness services. Angelcheva and Tomova (2023) examine apitherapeutic heritage and the application of honey and bee products in preventive and wellness practices. They highlight innovation opportunities in certified Bulgarian spa and wellness centres and the importance of specialized wellness education. Their findings demonstrate how traditional knowledge and natural resources can enrich contemporary wellness practices.

A similar relationship between Bulgarian natural resources, innovation, and wellness services is evident in the study by Popova-Dobreva (2023), which focuses on wellness innovations based on the Bulgarian rose (Rosa damascena). The author examines aromatherapeutic applications and the potential of the Bulgarian rose as a resource for the development of contemporary wellness practices, while also addressing the role of wellness education. This approach broadens the understanding of Bulgaria's competitiveness as a wellness destination, where natural and cultural heritage can serve as a foundation for innovative services and professional knowledge.

The multidimensional nature of health and well-being as outcomes associated with physical activity is further supported by Dimitrova (2025), whose study examines psychological, physical, and emotional well-being among students practicing judo. Although the research focuses on a specific sporting population, its findings demonstrate interrelationships among physical activity, physical fitness, psychosocial development, motivation, discipline, and social behaviour. This perspective is relevant to the broader conceptualization of wellness as a

multidimensional state in which the physical, psychological, and social dimensions of well-being are considered interrelated.

On this basis, the professional profile of the Wellness and Spa Consultant can be conceptualized as an interdisciplinary interface connecting professional education, health promotion, physical activity, wellness services, tourism, and human well-being. The role of the specialist should not be confined to knowledge of or promotion of individual spa procedures, but should encompass the capacity to provide professional guidance, understand individual needs, support healthy lifestyle practices, and direct consumers towards appropriate wellness activities and services, including those designed for specific categories of tourists, such as pregnant women, within the boundaries of professional competence (Petkova-Nesheva, 2026).

Methodology

The present study examines the *role of the Wellness and Spa Consultant in Bulgaria in promoting health, well-being, and sustainable development*. Its primary objective is to analyse the development of this professional profile within the national context and to assess its potential contribution to the contemporary wellness and spa sector, with particular emphasis on professional competencies, academic preparation, education–industry relations, and prospects for professional realization.

The study employs a targeted documentary review **(desk research)** with an analytical and descriptive approach. The sources analysed include: **(a)** official websites, news, and institutional documents of the National Sports Academy "Vasil Levski"; **(b)** admission guides and regulatory materials and **(c)** international reports of the Global Wellness Institute (GWI).

The data were analysed through *content, comparative, and thematic analysis* across seven key dimensions: academic development, professional competencies, health and well-being, education-industry relations, professional realization, human capital, and sustainable development.

The methodological framework follows the conceptual relationship *"Wellness and Spa Consultant → health → well-being → sustainable development."* As the first graduates are expected in 2027, the findings are interpreted as *emerging trends and potential prospects rather than definitive outcomes.*

Results and Analysis

The documentary analysis outlines the development of the professional profile ***"Wellness and Spa Consultant"*** in Bulgaria and demonstrates its potential contribution to promoting health, human well-being, and the sustainable development of the wellness and spa sector. The findings are presented according to the principal analytical dimensions of the study (Table 1), with particular emphasis on academic development, professional competencies, education–industry relations, professional realization, and prospects for sustainable development.

Table 1. Main dimensions of the documentary analysis

No.	Analytical Dimension	Primary Focus
1	**Academic Development**	Emergence and development of the Wellness and Spa Consultant professional profile
2	**Professional Competencies**	Knowledge, skills, and competencies required for professional practice
3	**Health and Well-being**	Potential contribution to health, quality of life, and human well-being
4	**Education–Industry Relations**	Interaction between academic education, employers, and the wellness and spa sector
5	**Professional Realization**	Employment opportunities, career development, and labour market needs

6	**Human Capital**	Contribution of qualified professionals to sectoral quality and competitiveness
7	**Sustainable Development**	Potential contribution to a sustainable and competitive wellness and spa sector

The Seven Analytical Dimensions

1. Academic Development of the Professional Profile - The analysis indicates that the introduction of the ***Wellness and Spa Consultant*** programme at the National Sports Academy represents a significant step towards the academic consolidation and professional advancement of the wellness and spa sector in Bulgaria. The professional profile establishes a structured educational framework for the development of specialists with interdisciplinary competencies.

2. Professional Competencies - The findings highlight the need to integrate knowledge and skills related to healthy lifestyles, physical activity, wellness services, communication, and professional counselling. This multidimensional competency framework reflects the increasingly complex nature of contemporary wellness.

3. Health and Well-being - The results indicate a potential role of the professional profile in promoting healthy behaviours, preventive approaches, and holistic human well-being. Within the scope of professional competence, the Wellness and Spa Consultant may support informed decision-making regarding appropriate wellness services and activities.

4. Education–Industry Interaction - The analysis highlights the need for closer alignment between academic preparation and the evolving requirements of the wellness, spa, tourism, and hospitality sectors. Stronger education–industry cooperation is essential for continuously updating professional competencies and enhancing the practical relevance of academic training.

5. Professional Realization - The continued expansion of wellness tourism creates favourable conditions for broader employment and career opportunities for qualified specialists. However, as the first graduates of the programme are expected in 2027, the present analysis does not permit a definitive assessment of actual employment outcomes.

6. Human Capital Development - Qualified professionals emerge as a critical resource for the quality, personalization, and competitiveness of wellness and spa services. Accordingly, academic preparation is relevant not only to individual professional development but also to the broader advancement of professional standards across the sector.

7. Potential Contribution to Sustainable Development - The Wellness and Spa Consultant may be conceptualized as a potential link between individual health, service quality, human capital development, and the sustainable advancement of the sector.

Overall Analytical Synthesis

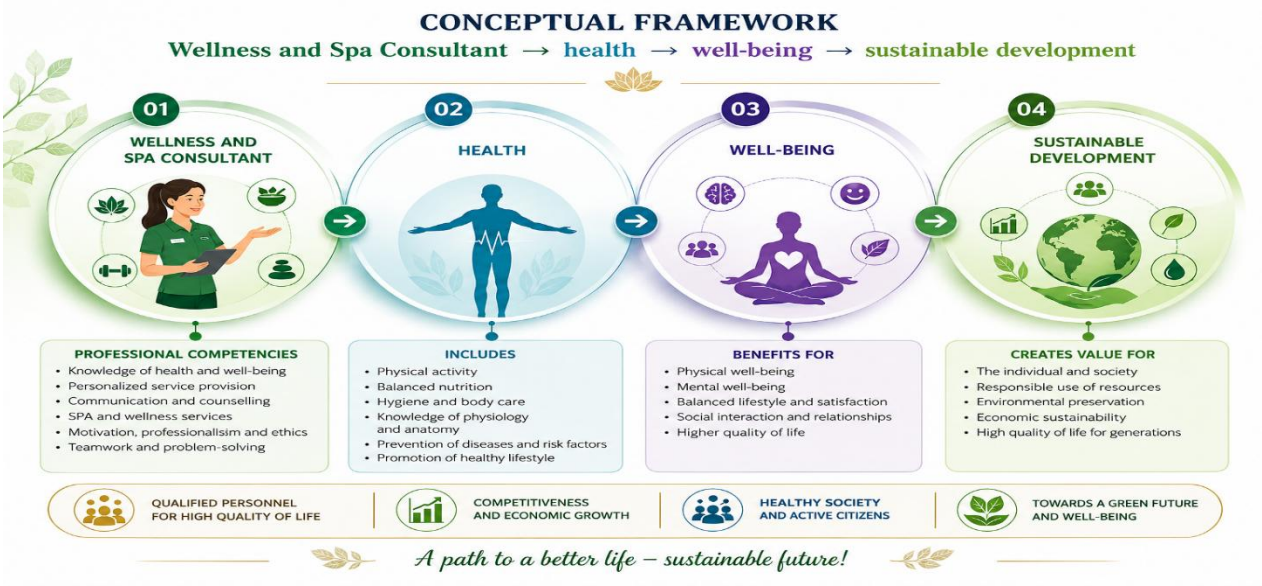
The findings indicate that the development of the ***Wellness and Spa Consultant*** professional profile responds to a growing demand for qualified specialists capable of integrating knowledge across health, physical activity, wellness services, and tourism. The analysis identifies a substantive interrelationship between professional competence, service quality, human well-being, and sustainable development, supporting the conceptualization of the consultant as a strategic interface between academic education and the evolving needs of the sector. Nevertheless, as the first graduates are expected in 2027, the present findings should be interpreted as *emerging trends and potential prospects rather than definitive evidence of professional realization.*

Discussion

The findings indicate that the role of the **Wellness and Spa Consultant** should be considered within a broader framework extending beyond the direct provision of wellness services. Professional education creates the potential to integrate knowledge of health, physical activity, well-being, and service quality with the evolving needs of the wellness and spa sector. In this context, the development of the professional profile may contribute

both to strengthening human capital and to fostering a more sustainable and competitive sector. This interrelationship is conceptually represented by the model *"Wellness and Spa Consultant → health → well-being → sustainable development"* as demonstrated in Fig. 1.

Figure 1. Conceptual model of the Wellness and Spa Consultant's role in promoting health, well-being, and sustainable development *Source: Author's own conceptual framework.*



This professional model assumes particular significance against the backdrop of the dynamic growth of the global wellness economy. As wellness tourism becomes an increasingly important component of tourism consumption, the quality of human resources emerges as a critical determinant of service quality, safety, personalization, and competitiveness. This is where the findings of the international literature on wellness tourism intersect with Bulgarian research conducted at the National Sports Academy on professional qualifications, standards, wellness culture, and educational programmes.

The introduction and development of professional education for the ***"Wellness and Spa Consultant"*** at the National Sports Academy "Vasil Levski" should therefore be considered within this broader scientific and professional framework. It provides an opportunity to systematize knowledge and competencies related to healthy lifestyles, physical activity, recreation, wellness services, and professional communication. Academic preparation creates potential for closer interaction between higher education and the wellness and spa industry and for developing professionals capable of responding to the evolving needs of the sector.

Within this framework, *professional competence represents the essential starting point; health promotion and prevention constitute the immediate areas of professional contribution; well-being represents the broader outcome for the individual; while sustainable development places individual well-being within the wider context of society, the economy, natural resources, and future generations.*

Accordingly, the role of the Wellness and Spa Consultant should be considered not only from a labour-market perspective but also as part of a broader process of professional development and quality enhancement within the wellness and spa sector. In this model, human capital becomes a connecting element between scientific knowledge, professional education, individual health and well-being, and the sustainable development of the tourism and wellness industries.

Conclusions

1. The ***"Wellness and Spa Consultant"*** professional profile represents a promising pathway for the academic and professional development of the Bulgarian wellness and spa sector, creating conditions for the preparation of qualified professionals with interdisciplinary competencies.
2. The analysis demonstrates a clear conceptual interrelationship between ***professional competence, health, human well-being, and wellness service quality***. Within this context, the Wellness and Spa Consultant has the potential to promote healthy lifestyles, informed decision-making, and individualized wellness practices.
3. The development of this professional profile offers potential for strengthening ***human capital and the sustainability of the Bulgarian wellness and spa sector;*** however, its actual impact on professional realization and the industry should be assessed through subsequent empirical research following the graduation of the first cohort of specialists.

Conclusion

The development of the wellness and spa sector is placing increasingly demanding requirements on professional education and the quality of human resources. In this context, the ***"Wellness and Spa Consultant"*** has the potential to emerge as a significant professional profile linking scientific knowledge, health promotion, service quality, and individual needs.

The analysis indicates that academic preparation can contribute not only to the professional realization of specialists but also to enhancing the quality and competitiveness of the sector. This is particularly relevant for Bulgaria, given its rich natural resources, established balneological traditions, and growing wellness tourism sector.

Ultimately, *investment in qualified professionals is a key factor in transforming Bulgaria's natural and tourism potential into high-quality, sustainable, and people-centred wellness and spa services.* The actual contribution of this professional profile remains to be evaluated through future research and by monitoring the professional realization of the first graduates.

Note:

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Indigenous Knowledge, Artificial Intelligence, Green Technology and Sustainable Development: A Commerce and Business Perspective

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Abstract: Indigenous knowledge represents the accumulated wisdom, practices, skills and experiences developed by local and indigenous communities over generations. Such knowledge encompasses agriculture, natural resource management, traditional production systems, biodiversity conservation, healthcare, water management and community-based economic practices. In the contemporary era, the integration of Indigenous Knowledge Systems (IKS) with Artificial Intelligence (AI) and green technologies provides new opportunities for sustainable economic development. Artificial Intelligence can support data analysis, forecasting, supply-chain optimization, market intelligence, resource management and decision-making, while green technologies can contribute to energy efficiency, waste reduction, renewable energy adoption and low-carbon production. The combination of traditional knowledge and modern technologies can therefore create innovative pathways for sustainable entrepreneurship, inclusive business models and environmentally responsible commerce.

From a commerce perspective, this integration has considerable relevance to sustainable business, green finance, rural entrepreneurship, agricultural marketing, supply-chain management, social enterprises and responsible consumption. AI can help convert locally available knowledge into actionable business intelligence, while green technology can improve production efficiency and reduce environmental costs. However, issues relating to intellectual property rights, data ownership, commercialization of indigenous knowledge, digital inequality, ethical AI, cultural preservation and environmental impacts of technology require careful consideration. This chapter examines the relationship between Indigenous Knowledge, Artificial Intelligence and Green Technology and explores their contribution to sustainable development, with particular emphasis on commerce and business practices. It proposes a framework for integrating traditional wisdom, technological innovation and responsible business practices to promote inclusive and sustainable economic growth.

Keywords: Indigenous Knowledge, Artificial Intelligence, Green Technology, Sustainable Development, Green Finance, Sustainable Business, Rural Entrepreneurship, Responsible Consumption, Innovation.

1. Introduction

Sustainable development has become a central concern for governments, businesses, communities and academic institutions. Economic growth alone is no longer considered sufficient for achieving long-term development. Contemporary development requires an appropriate balance among economic prosperity, social inclusion and environmental protection. The Sustainable Development Goals (SDGs) emphasize the need to address poverty, inequality, responsible consumption, climate change, decent employment, innovation and environmental sustainability.

Technological advancement has created new opportunities for addressing these challenges. Artificial Intelligence has emerged as one of the most influential technologies of the digital economy. It can analyses large volumes of data, identify patterns, forecast demand, automate processes and support decision-making. UN Trade and Development notes that AI can contribute to areas such as smart agriculture, energy systems, production, supply chains, water management and urban planning, provided that appropriate policies, infrastructure and skills are available.

At the same time, green technologies are transforming the way goods and services are produced and consumed. Renewable energy, electric mobility, energy-efficient technologies, circular production, sustainable packaging and waste-management technologies can reduce environmental pressures while creating new economic opportunities. UNCTAD highlights that green and frontier technologies can create opportunities for developing countries to diversify their economies, generate employment and strengthen technological capabilities.

Indigenous Knowledge adds another important dimension to this transformation. Indigenous and local communities have developed knowledge systems adapted to their specific ecological, social and economic environments. Traditional agricultural methods, water conservation, natural resource management, local crafts, medicinal plant knowledge and community-based resource-sharing practices demonstrate the potential of local knowledge for sustainable development.

The important question is therefore not whether traditional knowledge should be replaced by modern technology, but how traditional wisdom and modern technology can complement each other. AI can provide analytical capabilities, while Indigenous Knowledge can provide contextual and place-based understanding. Green technology can provide efficient technological solutions, while traditional practices can contribute principles of resource conservation and low-waste production.

From a commerce perspective, this convergence can support new business opportunities, sustainable enterprises, rural entrepreneurship, green finance and responsible supply chains.

2. Concept of Indigenous Knowledge

Indigenous Knowledge refers to knowledge developed and transmitted within communities over generations. It is generally associated with a particular geographical, cultural and ecological environment.

Indigenous Knowledge may include:

Traditional agricultural practices, Seed preservation and biodiversity management, Water conservation, Traditional food-processing methods, Natural resource management, Handicrafts and traditional industries, Traditional medicinal knowledge, Weather and climate observation, Community-based economic systems, Traditional construction practices, Local marketing and exchange systems

Unlike conventional scientific knowledge, which is frequently formalized through institutions and written documentation, Indigenous Knowledge is often transmitted through observation, practice, storytelling, community participation and intergenerational learning.

Its value is particularly significant in developing economies where rural communities continue to depend on natural resources and traditional occupations.

3. Indigenous Knowledge and Sustainable Development

Indigenous Knowledge has considerable potential to contribute to several dimensions of sustainable development.

3.1 Sustainable Agriculture

Traditional agricultural systems frequently emphasize crop diversity, seasonal adaptation, organic inputs, water conservation and local seed varieties. Such practices can reduce dependence on external inputs and improve resilience.

3.2 Water Management

Traditional water-harvesting structures, community-managed irrigation systems and locally developed conservation practices demonstrate how communities have historically responded to water scarcity.

3.3 Biodiversity Conservation

Local communities often possess detailed knowledge of plants, animals, forests and ecosystems. Such knowledge can support biodiversity conservation and sustainable resource utilization.

3.4 Sustainable Consumption

Traditional lifestyles often emphasize reuse, repair, sharing and low levels of material waste. These principles are closely related to contemporary concepts of circular economy and responsible consumption.

3.5 Rural Entrepreneurship

Traditional crafts, food products, textiles, herbal products and agricultural products can become sources of entrepreneurial income when supported by modern branding, e-commerce, digital marketing and supply-chain systems.

4. Artificial Intelligence and Sustainable Development

Artificial Intelligence refers to computational systems capable of performing tasks that traditionally require human intelligence, including learning, prediction, classification, pattern recognition and decision-making.

AI has applications across almost every sector of the economy.

Major applications include:

Predictive analytics, Demand forecasting, Customer relationship management, Fraud detection

Financial risk assessment, Supply-chain optimization, Agricultural forecasting, Energy management, Waste management, Environmental monitoring

UNCTAD's 2025 Technology and Innovation Report emphasizes three major requirements for inclusive AI development: infrastructure, data and skills. It also highlights the importance of policies that align AI development with national development priorities.

5. Artificial Intelligence and Commerce

AI is transforming the functions traditionally associated with commerce and management.

5.1 Marketing

AI can analyse consumer behaviour and identify purchasing patterns. Businesses can use predictive analytics to personalize marketing campaigns and improve customer engagement.

5.2 Finance

AI-based systems can support credit assessment, fraud detection, financial forecasting and risk management.

5.3 Banking

AI-powered chatbots, automated customer service, transaction monitoring and fraud detection have become important components of digital banking.

5.4 Supply Chain Management

AI can forecast demand, optimize inventory and identify disruptions in supply chains.

5.5 Human Resource Management

AI can support recruitment, workforce planning, employee analytics and training.

5.6 Entrepreneurship

AI lowers the cost of market research, business planning, customer analysis and digital promotion. This creates opportunities for small enterprises and rural entrepreneurs to participate in wider markets.

6. Green Technology: Meaning and Importance

Green technology refers to technologies designed to reduce negative environmental impacts while improving economic and social outcomes.

Important examples include:

Solar energy, Wind energy, Electric vehicles, Energy-efficient machinery, Green buildings, Waste-to-energy systems, Water-treatment technologies, Sustainable packaging, Precision agriculture, Smart energy systems, Recycling technologies, Circular production systems

Green technology is not only an environmental concept. It has become an important component of contemporary business strategy.

UNCTAD identifies green and frontier technologies as potential drivers of economic diversification, technological development and employment in developing economies.

7. Green Technology and Business

Businesses increasingly recognize that environmental sustainability can create economic value.

Green business practices can provide:

Reduction in energy costs, Reduction in material wastage, Improved operational efficiency

Better brand image, Access to environmentally conscious consumers, New market opportunities

Improved regulatory compliance, Long-term resource security

For example, a textile enterprise can reduce its environmental footprint by adopting energy-efficient machinery, water recycling, renewable energy and environmentally friendly dyes.
Similarly, retailers can adopt sustainable packaging and digital invoicing to reduce material consumption.

8. Integration of Indigenous Knowledge and Artificial Intelligence

The integration of Indigenous Knowledge with AI represents an emerging area of interdisciplinary research.
Indigenous Knowledge can provide context, while AI can provide analytical capability.
For example:
Indigenous Knowledge, AI Contribution ,Possible Outcome, Traditional weather observations, Predictive analytics, Improved agricultural planning, Traditional water management, Data modellingEfficient water allocation, Local crop knowledge ,Machine learning, Crop selection support, Traditional medicinal plant knowledge, Data organization, Knowledge documentation, Traditional handicrafts, Market analytics, Better market identification, Local resource knowledge, Geographic data analysisSustainable resource management
The objective should not be to use AI to replace indigenous communities. Instead, technology should be designed to strengthen community knowledge, livelihoods and decision-making.
UNESCO's Recommendation on the Ethics of Artificial Intelligence recognizes the importance of involving local and Indigenous communities in AI systems related to environmental protection and sustainable development.

9. Indigenous Knowledge and Green Technology

The relationship between Indigenous Knowledge and green technology is particularly relevant to sustainable production.
Traditional practices frequently contain principles such as:
Minimum resource consumption, Local sourcing, Reuse of materials, Repair and maintenance
Biodiversity protection, Seasonal production, Community cooperation, Waste reduction
These principles can complement modern green technologies.
For instance, traditional rainwater-harvesting knowledge can be combined with smart sensors to monitor water availability. Traditional agricultural knowledge can be complemented by AI-based weather forecasting and precision irrigation.
Thus, the objective is not a simple replacement of traditional methods with technology, but technology-enabled enhancement of sustainable traditional practices.

10. Commerce Perspective: Sustainable Entrepreneurship

One of the most important opportunities arising from this integration is sustainable entrepreneurship.
Traditional products can be transformed into modern commercial products through:
Indigenous Knowledge → Product Development → Green Production → Digital Marketing → E-Commerce → Sustainable Market
Examples include:
Traditional handicrafts, Organic agricultural products, Natural food products, Traditional textiles
Herbal products, Eco-friendly household products, Bamboo products, Traditional food-processing products
Digital platforms can enable rural entrepreneurs to access national and international consumers.
AI can further support these entrepreneurs through:
Market trend analysis, Price analysis, Customer segmentation, Digital advertising
Demand forecasting, Inventory management, Product recommendations
This can create a bridge between local knowledge and global markets.

11. Green Finance and Sustainable Development

Finance plays a critical role in supporting green technologies.
Green finance refers to financial activities that support environmentally sustainable projects and businesses.

Examples include:
Green bonds, Green loans, Sustainable investment funds, Renewable-energy financing
Climate finance, ESG-oriented investments, Sustainable banking products
Commerce and finance professionals can therefore contribute significantly to the transition towards a green economy.
Financial institutions can use AI to assess environmental and financial risks while identifying sustainable investment opportunities.

12. Artificial Intelligence in Sustainable Supply Chains
Modern supply chains face challenges relating to transportation costs, resource consumption, inventory management and carbon emissions.
AI can help businesses optimize supply chains by:
Forecasting demand, Optimizing transportation routes, Reducing excess inventory,
Monitoring suppliers, Predicting supply disruptions, Reducing food wastage, Improving warehouse management
When AI is combined with green technologies, businesses can develop more efficient and environmentally responsible supply chains.

13. Circular Economy and Indigenous Practices
The circular economy seeks to minimize waste and maximize the continued use of resources.
Traditional communities have historically practiced several principles that resemble circular economy models.
For example:
Repair → Reuse → Recycle → Repurpose → Share
Traditional practices such as repairing tools, reusing containers, converting agricultural residues into useful materials and sharing community resources can provide valuable lessons for contemporary circular businesses.
Modern technologies can scale these practices.
AI can identify material flows, predict waste generation and optimize recycling processes, while digital platforms can connect buyers and sellers of reusable materials.

14. Indian Context

India provides a particularly relevant context for studying the relationship among Indigenous Knowledge, AI, green technology and sustainable development.
The country has diverse traditional knowledge systems related to:
Agriculture, Water conservation, Forest management Handicrafts, Textiles, Food processing, Traditional medicine, Community institutions
Local entrepreneurship
At the same time, India is rapidly expanding its digital economy, AI capabilities, renewable-energy systems, digital payments and technology-enabled entrepreneurship.
This creates an opportunity to connect traditional knowledge with modern economic systems.
For example, a rural artisan cooperative can use:
Traditional craftsmanship + Digital payments + E-commerce + AI-based market analysis + Sustainable packaging to reach wider markets while preserving local knowledge and generating community income.

15. Opportunities for Commerce and Management
The convergence of these areas creates several research and business opportunities.
15.1 Rural Entrepreneurship
AI-enabled digital platforms can help rural entrepreneurs identify market opportunities.
15.2 Sustainable Marketing

Businesses can develop marketing strategies emphasizing environmental and social responsibility.
15.3 Green Supply Chains
Technology can support low-carbon logistics and resource-efficient production.
15.4 Social Enterprises
Social enterprises can commercialize traditional knowledge while generating community benefits.
15.5 Sustainable Tourism
Indigenous cultural knowledge can contribute to responsible and community-based tourism.
15.6 Digital Commerce
E-commerce can connect local producers with geographically distant consumers.
15.7 Green Banking
Banks can design financial products supporting renewable energy and sustainable enterprises.

16. Challenges and Ethical Issues
Despite the potential benefits, several challenges must be addressed.
16.1 Intellectual Property Rights
Indigenous Knowledge may be exploited commercially without appropriate recognition or benefit sharing.
16.2 Data Ownership
Digitizing indigenous knowledge raises questions regarding who owns and controls the resulting data.
16.3 Cultural Appropriation
Commercialization without community participation may lead to cultural exploitation.
16.4 Digital Divide
Communities with limited access to digital infrastructure may not benefit equally from AI and digital commerce.
16.5 AI Bias
AI systems trained on incomplete or inappropriate datasets may produce biased outcomes.
16.6 Environmental Cost of AI
AI itself consumes computing resources, electricity and data-centre infrastructure. Therefore, AI should not automatically be considered environmentally sustainable.
UNESCO emphasizes the need for data-, energy- and resource-efficient AI methods and recognizes the environmental implications of resource-intensive AI systems.
16.7 Skill Gaps
Successful technology adoption requires digital literacy, entrepreneurial skills and technical capabilities.

17. Proposed Integrated Framework
A sustainable commerce framework can be developed by integrating four components:
Indigenous Knowledge
Provides:
Local wisdom, Traditional practices, Cultural knowledge, Ecological understanding
Community experience,
↓
Artificial Intelligence
Provides:
Data analysis, Prediction, Decision support, Market intelligence, Process optimization
↓
Green Technology
Provides:
Resource efficiency, Renewable energy, Waste reduction, Low-carbon production
Sustainable infrastructure
↓

Sustainable Commerce
Produces:
Green enterprises, Rural entrepreneurship, Inclusive markets, Sustainable finance, Responsible consumption, Employment generation
↓
Sustainable Development
Contributes to:
Economic development, Social inclusion, Environmental protection, Community empowerment
Intergenerational sustainability
This framework demonstrates that Indigenous Knowledge and modern technology should be viewed as complementary rather than competing systems.

18. Recommendations

The following measures can strengthen the integration of Indigenous Knowledge, AI and green technology:
Document Indigenous Knowledge ethically with the active participation and consent of knowledge-holding communities.
Develop community-owned digital platforms that allow indigenous producers to market their products directly.
Promote AI literacy among rural entrepreneurs and small businesses.
Provide green finance for enterprises adopting environmentally sustainable technologies.
Protect intellectual property rights associated with traditional knowledge and cultural products.
Promote academia–industry–community collaboration for developing technology-based solutions.
Encourage sustainable entrepreneurship education in commerce and management programmes.
Develop ethical AI frameworks that protect privacy, cultural rights and community interests.
Support green supply chains for traditional products.
Measure both economic and environmental performance rather than focusing solely on financial profitability.

19. Conclusion

Indigenous Knowledge, Artificial Intelligence and Green Technology represent three important dimensions of the emerging sustainable economy. Indigenous Knowledge provides locally adapted wisdom and ecological understanding. Artificial Intelligence provides powerful analytical and decision-support capabilities. Green Technology provides mechanisms for reducing environmental impacts and improving resource efficiency.
Their integration can generate significant opportunities for commerce, particularly in rural entrepreneurship, sustainable marketing, green finance, digital commerce, supply-chain management and social enterprise development.
However, technological advancement should not result in the commercialization or appropriation of indigenous knowledge without community participation. Ethical data governance, intellectual property protection, digital inclusion and environmentally responsible AI are essential.
For commerce professionals, the emerging challenge is to move beyond the traditional objective of profit maximization towards responsible value creation. Businesses of the future must create economic value while protecting natural resources, respecting cultural knowledge and contributing to social well-being.
The future of sustainable development therefore lies not simply in adopting more advanced technology, but in creating an appropriate relationship between traditional wisdom, technological intelligence and responsible business practices. Such an approach can support inclusive growth and help transform local knowledge into sustainable economic opportunities while preserving ecological and cultural wealth for future generations.

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Applying Basic Sports-Science Concepts to the Analysis of Traditional Physical Activities

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Abstract: Sports science and indigenous physical culture are important areas of human movement, physical development and cultural heritage. Indigenous communities have developed traditional games, martial arts, wrestling, running, jumping and other physical activities that promote strength, endurance, agility, balance, coordination and teamwork. This chapter explores how basic sports-science concepts such as exercise physiology, biomechanics, motor learning, fitness and sports psychology can be applied to understand traditional physical activities. Examples such as kabaddi and Silambam demonstrate the physical and psychological demands of indigenous practices. The chapter also highlights their importance in physical education, health promotion and cultural preservation. It emphasizes that scientific analysis should complement, rather than replace, indigenous knowledge and should respect community ownership and cultural values. Integrating sports science with indigenous physical culture can promote safe participation, meaningful education and the preservation of traditional movement practices for future generations.

Keywords: *Sports Science, Indigenous Physical Culture, Traditional Games, Physical Education, Kabaddi, Silambam, Biomechanics, Cultural Heritage.*

Introduction

Traditional physical activities represent an important component of the cultural and physical heritage of communities. They include indigenous games, martial arts, wrestling, running, jumping, throwing, traditional dances and other forms of movement that have been transmitted across generations. Although many of these activities originated before the development of modern sports science, they involve complex physical, physiological, biomechanical, psychological and social demands.

Sports science provides systematic methods for understanding these demands. Basic concepts from exercise physiology, biomechanics, kinesiology, motor learning, sports psychology and fitness assessment can be applied to traditional physical activities without removing their cultural significance. Such analysis helps students, teachers, coaches and researchers understand how traditional activities contribute to physical development and how they can be safely incorporated into contemporary physical education.

The purpose of scientific analysis is not to replace indigenous knowledge with modern scientific knowledge. Rather, it is to establish a dialogue between traditional experience and scientific observation. Traditional practitioners possess valuable practical knowledge developed through repeated experience, while sports science provides standardized concepts and methods for describing movement, physical effort and performance.

Meaning of Sports-Science Analysis

Sports-science analysis refers to the systematic examination of physical activity using scientific principles. It involves identifying the physical demands of an activity, observing movement patterns, assessing physiological responses, examining skill requirements and understanding psychological and social factors.

Analysis Through Physical Fitness Components

One of the simplest ways to apply sports science to traditional activities is to identify the physical fitness components involved.

Exercise Physiology and Traditional Activities

S.No	Component	Short Explanation
1.	Heart Rate	Indicates the cardiovascular response to exercise. It usually increases with activity intensity and can be measured during Rest → Warm-up → Activity → Recovery.
2.	Energy Systems	The body uses ATP-PC, Anaerobic Glycolytic, and Aerobic energy systems depending on the intensity and duration of the activity.
3.	Oxygen Consumption	Indicates the aerobic demand of an activity. It can be assessed using oxygen measurement equipment or simple indicators such as heart rate and perceived exertion.
4.	Fatigue	Repeated or intense activity may temporarily reduce physical performance and movement efficiency.
5.	Recovery	Recovery can be monitored through heart-rate recovery, perceived exertion, rest time, movement quality, and performance consistency.

Biomechanical Analysis of Traditional Activities

Biomechanics is the study of movement using principles of mechanics. It provides an important framework for analyzing traditional physical activities.

Centre of Gravity

The body's centre of gravity is important for maintaining stability. A person generally becomes more stable when the centre of gravity is maintained appropriately within the base of support.In wrestling and martial activities, participants continuously manipulate body position to maintain their own stability while attempting to disturb the opponent's balance.

Base of Support

The base of support refers to the area beneath and between the points of contact with the supporting surface.A wider base can generally improve stability, while a narrower base may allow greater mobility but can require more precise balance control.

This principle can be observed in traditional martial arts, wrestling and various traditional games.

Force

Force is fundamental to human movement. Participants generate muscular force to accelerate the body, jump, throw, push or resist an opponent.

Traditional activities can therefore be used to teach students about:

- Force production
- Direction of force
- Ground reaction force
- Resistance
- Acceleration
- Momentum

Momentum

Momentum is associated with the mass and velocity of a moving body. In activities involving running, collision, evasion or controlled body contact, momentum influences movement outcomes.Understanding momentum can help explain why changes in body position, speed and direction affect performance.

Levers and Joint Movement

The human body functions through a system of bones and joints that can be analyzed using lever principles.Traditional throwing, striking, jumping and lifting activities provide practical examples of how joint positions influence mechanical advantage and movement efficiency.

Motor Learning and Traditional Physical Activities

Motor learning examines how individuals acquire and improve movement skills.

Traditional physical activities often provide excellent environments for motor learning because they involve repeated practice, observation, imitation, feedback and adaptation.

Important motor-learning principles include:

- Practice
- Repetition
- Feedback
- Demonstration
- Progression
- Variation
- Decision-making
- Transfer of learning

For example, a learner practicing Silambam must gradually coordinate footwork, body position, hand movements, timing and control. Repeated practice allows the learner to develop increasingly efficient movement patterns.Traditional games also encourage implicit learning because participants often learn through playing rather than through formal theoretical instruction.

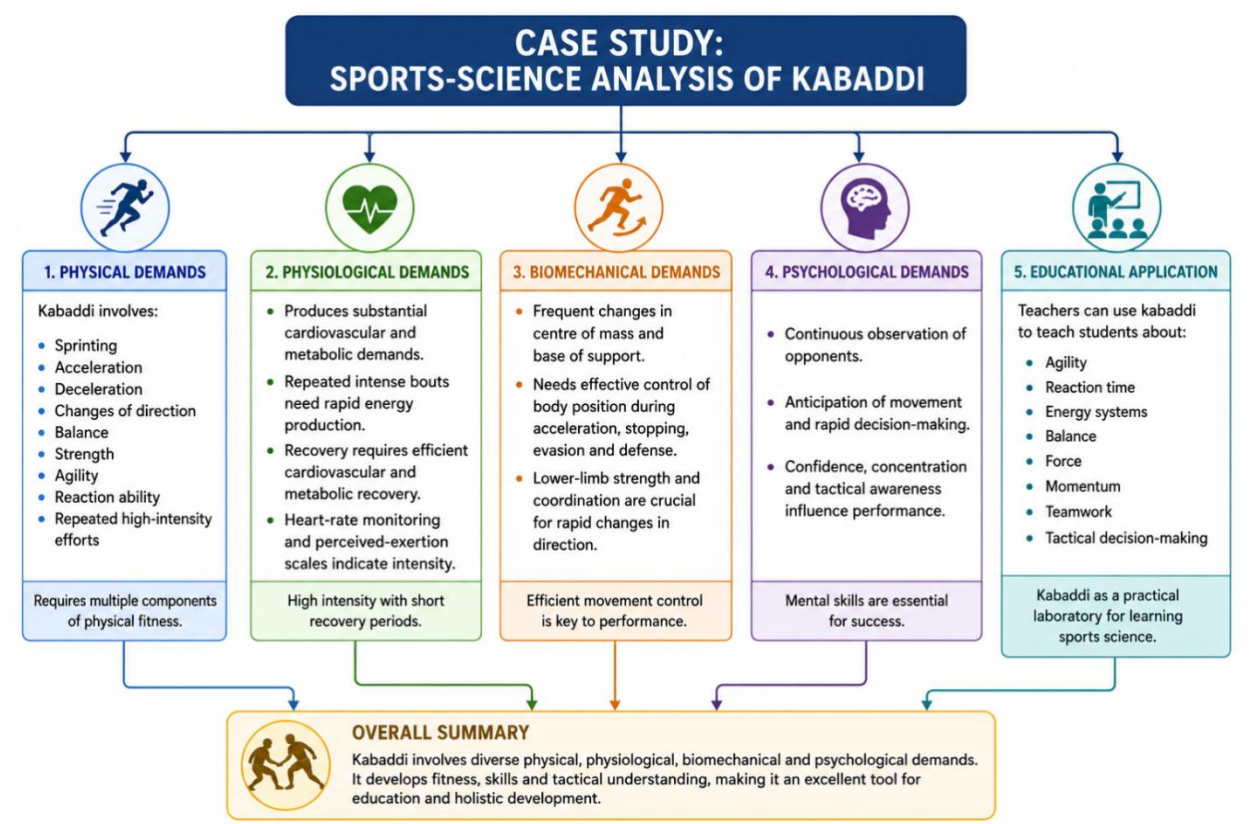
Psychological Analysis

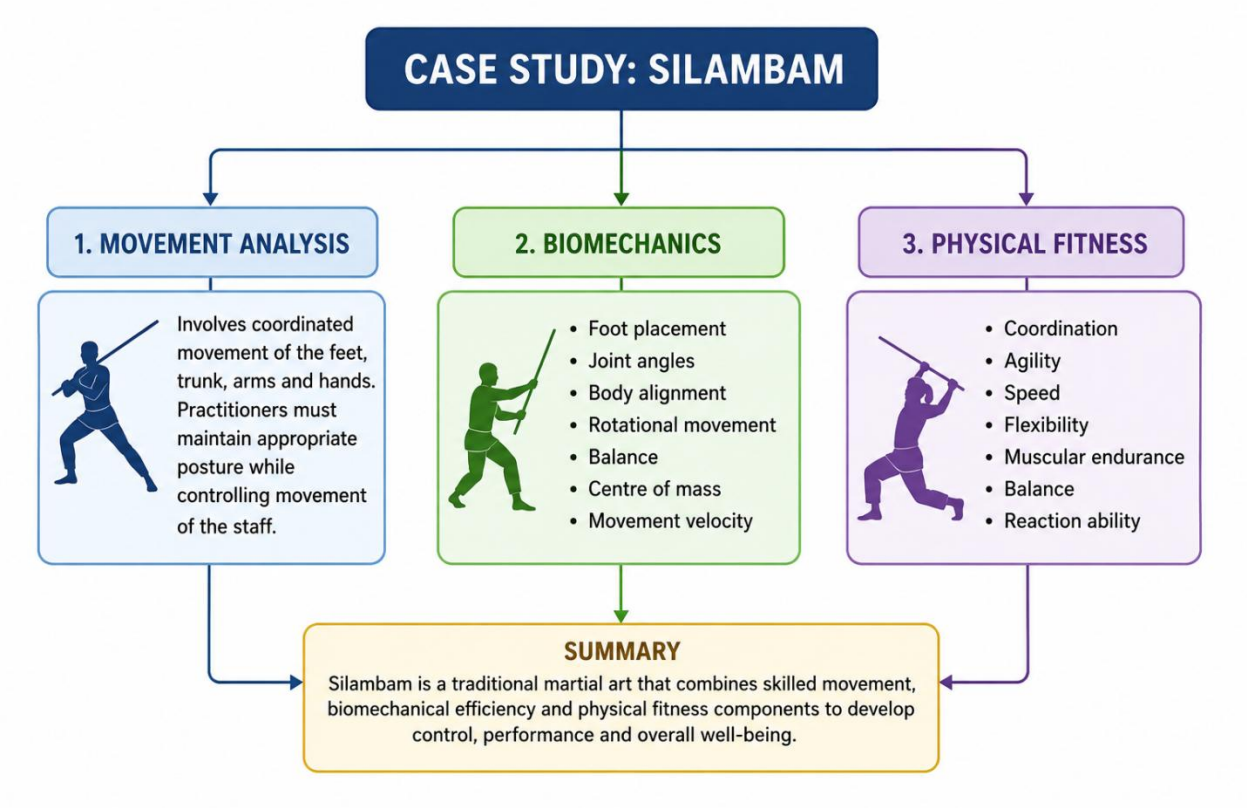
Physical performance is influenced not only by physiological and biomechanical factors but also by psychological factors.

Traditional physical activities may develop:

- Concentration
- Confidence
- Motivation
- Decision-making
- Emotional control
- Team cooperation
- Competitive behaviour
- Persistence

In team-based games such as kabaddi, players must communicate and make rapid tactical decisions. The psychological demands of the activity can therefore be analyzed alongside its physical demands.Researchers may use questionnaires, interviews, observation and performance measures to study these dimensions.





The exact physical demands vary according to the style, level and training session.

Motor Learning

Beginners generally require progressive learning of basic footwork and movement patterns before attempting more complex combinations. Demonstration, repetition and feedback are important components of skill development.

Importance of Cultural Context

Scientific analysis should never separate an indigenous activity completely from its cultural context. A traditional game is not simply a collection of movements. It may represent community identity, historical memory, social relationships and cultural knowledge.

Therefore, sports scientists and physical educators should work with practitioners and communities when documenting traditional activities. Scientific analysis should support preservation and education rather than inappropriate commercialization or cultural appropriation.

The objective is to understand the activity more deeply while respecting the people and communities who have preserved it.

Conclusion

Applying basic sports-science concepts to traditional physical activities provides an effective way of connecting scientific knowledge with cultural heritage. Traditional games and physical practices can be examined through physical fitness, exercise physiology, biomechanics, motor learning and sports psychology.

Kabaddi, Silambam, wrestling, traditional running and jumping games and other indigenous activities provide practical examples of how human movement can be studied scientifically. Such analysis can help teachers understand the physical demands of activities, develop appropriate training programmes, improve safety and create culturally relevant learning experiences.

At the same time, scientific analysis should not reduce indigenous physical culture to numbers, measurements or performance outcomes alone. Traditional practices possess cultural, historical, educational and social meanings that must be respected. A balanced approach combines scientific investigation with community knowledge and cultural sensitivity.

Therefore, the application of sports science to indigenous physical culture should be understood as a process of integration rather than replacement. When traditional knowledge and modern scientific approaches are brought together responsibly, they can contribute to physical education, sports performance, health promotion, cultural preservation and the holistic development of individuals and communities.

RECOMMENDATIONS

1. **Integrate Indigenous Activities:** Include traditional games and physical practices in Physical Education programmes.
2. **Promote Scientific Research:** Study indigenous activities using sports-science methods.
3. **Document Traditional Practices:** Preserve endangered activities through records, photos, videos and interviews.
4. **Develop Relevant Training:** Use traditional activities to improve fitness and motor skills.
5. **Train Physical-Education Teachers:** Educate teachers about indigenous games, sports science and safe adaptations.
6. **Ensure Safety:** Follow proper warm-up, progression, supervision and training principles.
7. **Encourage Interdisciplinary Research:** Promote collaboration among sports scientists, historians, psychologists and cultural researchers.
8. **Use Modern Technology:** Apply video analysis, heart-rate monitors and motion-analysis tools appropriately.
9. **Respect Cultural Ownership:** Recognize and obtain consent from communities and traditional practitioners.
10. **Encourage Youth Participation:** Create opportunities for young people to learn traditional physical activities.
11. **Promote Inclusion:** Adapt activities for participants of different abilities and backgrounds.
12. **Develop Community Programmes:** Organize festivals, workshops and demonstrations with community support.
13. **Create Evidence-Based Guidelines:** Develop scientific guidelines for safe teaching and training.
14. **Encourage Comparative Studies:** Compare traditional and modern training methods objectively.
15. **Support Preservation:** Protect indigenous physical culture while ensuring sustainable development and participation.

Overall Recommendation

The integration of sports science with indigenous physical culture should follow a **“science with culture” rather than “science replacing culture”** approach. Scientific principles can help explain movement, physical demands, training responses and safety, while indigenous knowledge provides cultural meaning, practical experience and community identity. A collaborative approach involving practitioners, teachers, researchers, students and communities can ensure that traditional physical activities remain relevant, scientifically informed, safe and accessible for future generations.

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SMART VILLAGES AND RURAL DEVELOPMENT

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Abstract: The development of a nation depends on the social and economic well-being of its citizens. Since a large proportion of India's population lives in rural areas, national development cannot be achieved without balanced rural development. Villages contribute significantly to agriculture, livestock, food security, employment and the rural economy. The concept of Smart Villages aims to improve rural living standards through modern infrastructure, digital technology, renewable energy, better healthcare, education, transportation, water, sanitation, agricultural development and local employment. This chapter examines the existing problems of rural communities and discusses how Smart Villages can promote sustainable and inclusive rural development while preserving the natural and cultural character of villages.

1. INTRODUCTION

India is a country where rural and urban areas are closely interconnected. Villages play an important role in agriculture, livestock, food production, employment and natural-resource management. Many rural communities continue to face challenges relating to roads, transportation, education, healthcare, housing, drinking water, sanitation, electricity, digital connectivity, markets and employment.

A **Smart Village** may be defined as a rural community that uses modern infrastructure, digital technology, innovation, renewable energy and local resources to improve the quality of life strengthen the local economy and provide sustainable public services.

The major objectives of Smart Village development are to:

1. Improve rural infrastructure and basic services.
2. Reduce the rural–urban development gap.
3. Improve agricultural productivity and farmers' income.
4. Create local employment and entrepreneurship opportunities.
5. Improve access to education and healthcare.
6. Promote digital and financial inclusion.
7. Encourage renewable energy and environmental protection.
8. Reduce unnecessary rural–urban migration.
9. Strengthen disaster preparedness.
10. Preserve the cultural and environmental identity of rural communities.

2. EXISTING SCENARIO IN THE VILLAGES OF INDIA

2.1 Transportation in the villages

Transportation problems affect students, farmers, elderly people, pregnant women and patients requiring emergency medical care. Good all-weather roads, regular bus services, ambulance facilities and agricultural transport are therefore essential for rural development.

2.2 Education

Some rural children have to travel several kilometers to attend schools. Lack of transportation, inconvenient bus timings, poverty and long travelling distances may discourage students from continuing their education.

2.3 Housing and Sanitation

A healthy rural house should have adequate ventilation, clean cooking facilities, electricity, a toilet, bathroom, safe drinking water, proper drainage and scientifically designed waste-disposal facilities.

2.4 Medical Facilities

Medical emergencies require immediate attention. Delays caused by poor transportation can increase health risks. Primary healthcare facilities, trained health workers, ambulance services, essential medicines and telemedicine facilities are therefore important components of rural development.

2.5 Water

Rainwater harvesting, groundwater recharge, restoration of ponds and tanks, watershed management and efficient irrigation can improve water security.

2.6 Electricity

Reliable electricity is necessary for households, education, healthcare, irrigation, agriculture, communication and rural industries. Although electricity access has improved significantly, interruptions and inadequate quality of supply can still affect rural activities.

Renewable energy systems such as solar power, wind energy and biogas can supplement grid electricity and improve energy security.

2.7 Public Safety

Community participation, access to police, adequate street lighting, quick access to emergency services, awareness programmes and effective local governance can improve rural safety.

2.8 Environment and Recreation

Deforestation, open waste disposal, wastewater discharge, open burning and excessive use of natural resources can damage the rural environment.

Villages should also be provided with parks, playgrounds, libraries, community halls and sports facilities. These facilities are important for children's development, physical fitness, recreation, and community interaction.

2.9 Access to Government and Financial Services

Digital banking, Common Service Centres, online government services, digital payments and mobile-based services can significantly improve accessibility. Digital literacy should accompany digital infrastructure.

3. SMART VILLAGES

3.1 Concept of a Smart Village

A Smart Village should be:

- Economically productive
- Socially inclusive
- Digitally connected
- Environmentally sustainable
- Energy efficient
- Water secure
- Healthy and safe
- Employment oriented
- Disaster resilient
- Community driven

3.2 Electrical Power and Renewable Energy

Electricity is the foundation of modern rural development. It is required for households, schools, hospitals, irrigation, industries, shops, communication and digital services.

Smart Villages should increasingly use renewable energy sources such as solar, wind, small hydro and biogas. Solar panels can be installed on houses, schools, public buildings and agricultural structures.

Battery storage can store electricity generated from renewable sources and provide power when generation is low. Households that generate electricity for their own consumption and supply surplus electricity to the grid can become **prosumers**, meaning both producers and consumers of electricity.

Smart meters can record electricity consumption, generation, grid import and grid export and can help households manage energy efficiently.

3.3 Solid Waste and Energy Generation

Waste-to-energy systems may also be used where technically, economically and environmentally appropriate.
Waste segregation at source is essential. Recyclable, biodegradable, hazardous and non-recyclable waste should be separated.
The basic principle should be:
Reduce → Reuse → Recycle → Recover → Dispose Safely

3.4 Cattle and Poultry

Cattle and poultry are important sources of milk, meat, eggs, manure and rural income. Animal dung and organic waste can be used for biogas production and composting. Scientific livestock management can improve both productivity and public health.

3.5 Water Conservation and Safe Drinking Water

Water security is essential for a Smart Village. Rainwater should be harvested through rooftop systems, ponds, farm ponds, check dams, recharge wells and other suitable structures. Groundwater recharge and watershed development can improve water availability. Efficient irrigation methods such as drip and sprinkler irrigation can reduce water wastage.
Every household should have access to safe and reliable drinking water. Water should be regularly tested and treated wherever necessary.
The principle should be:
"Every drop of water should be conserved, used efficiently and reused wherever possible."

3.6 Drainage and Wastewater Management

Rainwater and domestic wastewater should be managed separately wherever possible. Household wastewater should be collected through appropriate drainage systems and treated before discharge or reuse.
Treated wastewater can be reused for gardening, landscaping, tree planting and other suitable purposes after ensuring appropriate treatment and safety.

3.7 Smart Housing

Houses should have adequate:

- Natural light and ventilation
- Living space
- Clean cooking facilities
- Toilets and bathrooms
- Safe drinking water
- Drainage
- Electricity
- Safe electrical wiring
- Space for renewable-energy systems

Home automation can be introduced where economically feasible. Sensors can help control lights, fans, pumps and other appliances and thereby reduce unnecessary energy consumption.

3.8 Telecommunications and Digital Connectivity

Reliable internet and mobile connectivity are essential for a Smart Village.
Digital connectivity enables villagers to access:

- Online education
- Telemedicine
- Digital banking
- Government services
- Agricultural information

- Weather forecasts
- Market prices
- E-commerce
- Digital payments
- Employment opportunities

Fiber-optic networks, mobile networks, community digital centers and affordable digital devices can reduce the rural–urban digital divide.

3.9 Healthcare

A Smart Village should provide access to primary healthcare, trained health workers, essential medicines, diagnostic facilities, emergency transportation and referral services.

A healthcare centre can serve a cluster of villages. Telemedicine can connect rural patients with specialists in towns and cities.

3.10 Transportation

Good roads and reliable public transportation are essential for connecting villages with schools, hospitals, markets, workplaces and government offices.

A Smart Village should have:

- All-weather roads
- Regular bus services
- Ambulance facilities
- Safe pedestrian pathways
- Agricultural transport facilities
- Electric-vehicle charging facilities where appropriate

Improved transportation can reduce travel time and increase access to education, healthcare, employment and markets.

3.11 Education

Primary and elementary schools should be available within reasonable reach.

Secondary and higher secondary schools can serve a cluster of villages. Digital classrooms, online learning, digital libraries, smart boards and internet facilities can supplement conventional education.

3.12 Smart Agriculture

Important technologies and practices include:

- Soil testing
- Weather-based agricultural advisories
- Soil-moisture monitoring
- Drip and sprinkler irrigation
- Farm mechanization
- Precision agriculture
- Drone-based crop monitoring
- Integrated pest management
- Scientific storage
- Digital market information

Mechanization can improve efficiency in ploughing, sowing, harvesting, weeding and other agricultural activities.

3.13 Storage, Processing and Marketing

Smart Villages should promote warehouses, cold storage, milk collection centres, food-processing units, packaging facilities, Farmer Producer Organisations, cooperatives and digital marketing platforms.

3.14 Recreation and Community Facilities

Parks, playgrounds, libraries, community halls, sports centres, cultural centres and youth clubs should be provided in Smart Villages. These facilities promote physical fitness, mental well-being, social interaction, cultural activities and community participation.

3.15 Disaster Management

A Smart Village should have:

- Early-warning systems
- Emergency communication
- Evacuation routes
- Safe shelters
- Emergency medical facilities
- Rescue equipment
- Emergency food and water
- Community disaster-response teams

Mobile alerts, weather information, sensors and other digital technologies can improve disaster preparedness.

3.16 Rural Employment and Entrepreneurship

Employment opportunities can reduce unnecessary migration to cities.

Suitable activities include:

- Food processing
- Dairy
- Poultry
- Handicrafts
- Textiles
- Agro-based industries
- Renewable-energy services
- Digital service centers
- Rural tourism
- Repair and maintenance services
- Small and medium enterprises

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3.18 Digital Governance

Villagers should be able to access services relating to:

- Government certificates
- Welfare schemes
- Land records
- Pension
- Banking
- Ration services
- Property services
- Grievance registration
- Employment services

However, digital services should be supported by local assistance for elderly persons, persons with disabilities and digitally excluded citizens.

3.19 Environmental Protection

Smart Village development should protect agricultural land, forests, ponds, lakes, wetlands, common lands, biodiversity and open spaces.

Renewable energy, water conservation, waste recycling, wastewater reuse, afforestation, sustainable agriculture and energy-efficient buildings should be promoted.

Modernization should therefore take place without destroying the ecological identity of rural communities.

3.20 Open Space and Land-Use Planning

Adequate open space is an important feature of rural life. Smart Village planning should maintain a suitable balance between built-up areas and open spaces.

Land Use Type	Suggested Share	Examples
Built-up Area	20–40%	Houses, shops, schools, public buildings and roads
Open/Unbuilt Area	60–80%	Agricultural land, forests, wetlands, ponds, lakes, parks and open spaces

4. SMART VILLAGES AND RURAL DEVELOPMENT

Smart Village development should focus on improving the economic and social well-being of rural residents. Agricultural land is often located outside the main settlement. Good roads and transport systems are therefore necessary to move seeds, fertilizers, machinery, agricultural products and other materials. Modern technology and mechanization can reduce physical labour and improve productivity. Storage, processing, transportation and digital marketing can help farmers obtain better value for their products. Employment should also be created within or near villages. Agro-processing units, small industries, educational institutions, healthcare facilities, renewable-energy enterprises, warehouses, tourism activities and service businesses can provide local employment.

However, industrial development should be carefully planned to protect agricultural land, water resources, forests and residential areas.

5. CONCLUSION

Smart Villages represent a modern approach to inclusive and sustainable rural development. The objective is not to convert villages into cities but to provide rural residents with reliable infrastructure, quality education, healthcare, safe water, sanitation, electricity, digital connectivity, transportation, agricultural support, employment and recreation. Renewable energy, digital technology, smart agriculture, water conservation, waste management and local entrepreneurship can improve rural productivity and quality of life. At the same time, agricultural land, open spaces, water bodies, biodiversity, culture and traditional community relationships must be protected. A successful Smart Village can reduce the rural–urban divide, create local employment, strengthen agriculture, empower women and youth, improve public services and reduce unnecessary migration.

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Green Geospatial Intelligence: Artificial Intelligence for Environmental Conservation and Climate Resilience

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Abstract: Environmental degradation, biodiversity loss, and the increasing impacts of climate change have created an urgent need for intelligent and sustainable approaches to environmental management. Recent advances in artificial intelligence (AI) and geospatial technologies have transformed the way environmental data are collected, analysed, and interpreted, enabling more informed and timely decision-making. This chapter explores the concept of Green Geospatial Intelligence, which combines AI techniques with Geographic Information Systems (GIS), remote sensing, satellite imagery, and spatial data analytics to support environmental conservation and strengthen climate resilience. The chapter discusses how machine learning, deep learning, and computer vision can improve the monitoring of forests, wildlife habitats, land use changes, water resources, and natural disasters. It also highlights the role of geospatial intelligence in identifying environmental risks, predicting climate-related events, and supporting sustainable resource management. Beyond technological advancements, the chapter examines challenges such as data quality, computational demands, ethical considerations, and the need for interdisciplinary collaboration. Furthermore, it outlines emerging opportunities, including Green AI, edge computing, and Earth observation technologies, that can enhance environmental monitoring while reducing energy consumption. By bringing together sustainable computing and geospatial intelligence, this chapter demonstrates how AI-driven solutions can contribute to environmental protection, climate adaptation, and evidence-based policy development. It aims to provide researchers, practitioners, and policymakers with a comprehensive understanding of the growing role of intelligent geospatial technologies in achieving long-term environmental sustainability and supporting global climate action.

Keywords: *Green Geospatial Intelligence; Artificial Intelligence (AI); Geographic Information Systems (GIS); Remote Sensing; Machine Learning; Environmental Conservation; Climate Resilience; Sustainable Development; Earth Observation; Spatial Data Analytics.*

Introduction

Environmental systems are constantly changing. Forests are being cleared, habitats are becoming fragmented, water resources are under increasing pressure, and many regions are experiencing
more frequent climate-related events. Understanding these changes requires information that is accurate, timely, and capable of showing how environmental conditions vary across different locations. Traditional field-based surveys remain important, but they can be difficult to conduct continuously across large and remote areas. This has increased the importance of technologies that can observe and analyse the environment on a larger scale.
Geospatial technologies such as Geographic Information Systems (GIS), satellite imagery, remote sensing, and spatial databases have become valuable tools for environmental studies. They allow researchers to observe forest cover, agricultural land, water bodies, and changes caused by natural
disasters. However, the large amount of spatial information available today makes manual analysis time-consuming and challenging.
Artificial Intelligence (AI) provides new ways to process this information. Machine learning and deep learning techniques can identify patterns in large datasets and support applications such as land-cover classification, change detection, vegetation assessment, wildfire identification, and environmental risk mapping. Combining AI with geospatial technologies can therefore improve environmental monitoring and support more informed decision-making.

This chapter uses the term Green Geospatial Intelligence to describe the integration of intelligent computing and geospatial technologies for environmentally responsible applications. It also
considers the sustainability of the technologies themselves, since processing large satellite datasets and complex AI models can require considerable computational resources. Energy efficiency and responsible data processing are therefore important aspects of developing sustainable AI-based environmental solutions.
One major application is environmental conservation. AI-supported geospatial analysis can assist in detecting deforestation, monitoring wildlife habitats, mapping biodiversity, and assessing ecosystem changes.
Green Geospatial Intelligence can also contribute to climate resilience. Floods, droughts, wildfires, landslides, and coastal erosion can significantly affect both ecosystems and communities.
Geospatial information can identify vulnerable areas, while AI-based methods can support risk assessment, prediction, and early-warning systems.

1. Green Geospatial Intelligence: Concept and Foundations

The growing availability of environmental data has changed the way natural resources and
ecosystems are studied. Information collected through satellites, sensors, drones, and geographical databases can provide a detailed view of changes taking place across different regions. Geospatial intelligence brings together this location-based information with analytical techniques to understand environmental conditions and support decision-making.

Concept of Green Geospatial Intelligence

Green Geospatial Intelligence refers to the use of geospatial technologies and Artificial Intelligence (AI) for environmental applications while giving attention to the sustainability of the computing
processes involved. The objective is not only to obtain useful information about the environment but also to encourage efficient use of computational resources. This becomes particularly important when large satellite images and other spatial datasets require considerable processing power.
The concept therefore connects environmental monitoring with sustainable computing. Instead of viewing technology only as a tool for analysing nature, Green Geospatial Intelligence also
considers how computing resources can be used responsibly while developing environmental solutions.

1.1 Role of Artificial Intelligence in Geospatial Analysis

AI adds an intelligent layer to geospatial analysis. Traditional GIS methods can display, organize, and analyse spatial information, while AI techniques can learn patterns from large datasets and assist in classification, prediction, and change detection.
For example, an AI model can analyse satellite images from different years to identify areas where forest cover has decreased. Similar methods can be applied to monitor water bodies, agricultural land, wildlife habitats, and areas affected by natural disasters. This reduces the dependence on completely manual analysis and can help researchers process large amounts of information more efficiently.

1.2 Remote Sensing and Satellite-Based Observation

Remote sensing is another important foundation of Green Geospatial Intelligence. Satellites and other remote-sensing platforms collect information without requiring direct physical access to the area being studied. This makes remote sensing particularly useful for observing forests, oceans, mountains, agricultural regions, and other difficult-to-reach environments.
When remote sensing data are combined with GIS and AI, environmental changes can be examined over both space and time. Repeated observations can help reveal changes in vegetation, land use, water resources, and ecosystems. Such information can support conservation planning and environmental assessment

1.3 Geographic Information Systems and Spatial Data

Geographic Information Systems (GIS) provide the framework for storing, managing, analysing, and visualizing information linked to geographical locations. GIS can combine different layers of information, such as forest cover, rainfall, temperature, roads, rivers, and protected areas, within a single spatial environment.

The integration of GIS with AI makes it possible to identify relationships and patterns within these datasets. For environmental conservation, this can assist in locating vulnerable ecosystems, mapping habitat changes, and supporting decisions related to natural resource management.

Technologies Behind Green Geospatial Intelligence

1.4 Geographic Information Systems (GIS)

GIS is a computer-based technology used to store, manage, analyse, and visualize information associated with geographical locations. Unlike ordinary databases, GIS can connect information with a specific position on the Earth's surface. This makes it useful for studying relationships between environmental factors and their locations.

In conservation, GIS can be used to create maps of forests, rivers, protected areas, agricultural regions, and wildlife habitats. Different layers of information can be combined to identify areas that may require protection or further investigation. When GIS is integrated with AI, these spatial datasets can be analysed more efficiently and used for prediction and automated classification.

1.5 Remote Sensing and Satellite Imagery

Remote sensing provides information about the Earth's surface using satellites, aircraft, drones, and other sensing platforms. It is particularly useful for environmental monitoring because observations can be collected repeatedly without physically visiting every location.

Satellite imagery can reveal changes in vegetation, land use, water bodies, and coastal regions. Comparing images collected at different times can help identify environmental changes. AI-based image analysis can further assist in detecting these changes and reducing the amount of manual interpretation required.

1.6 Artificial Intelligence and Machine Learning

AI enables computer systems to perform tasks that normally require human reasoning or pattern recognition. Within environmental geospatial applications, machine learning is commonly used to classify spatial data, recognize environmental features, and generate predictions.

For example, a machine learning model can be trained using satellite images containing different land-cover categories. Once trained, it can classify new images and help identify changes in forests, agricultural areas, or urban regions. The effectiveness of such systems depends on the quality and representativeness of the training data.

1.7 Deep Learning and Computer Vision

Deep learning has expanded the ability of computers to interpret complex images. Convolutional neural networks and related architectures can learn visual features directly from image data, making them useful for analysing satellite and aerial imagery.

Computer vision techniques can support applications such as forest-fire detection, crop monitoring, vegetation analysis, and identification of changes in land cover. However, deep learning models may require large datasets and considerable computational resources. This creates a need for efficient model design when sustainability is an important consideration.

1.8 Cloud and Edge Computing

Cloud computing provides access to storage and processing resources without requiring all computational infrastructure to be maintained locally. This can be useful when environmental

projects involve large volumes of satellite and sensor data. Edge computing takes some processing closer to where the data are generated. For example, an environmental sensor or drone may perform initial analysis before sending selected information to a central server. This can reduce
data transmission and response time. In combination with AI, edge computing can support real-time environmental monitoring while potentially reducing unnecessary data movement.

2. Applications of Green Geospatial Intelligence in Environmental Conservation

Green Geospatial Intelligence has applications across several areas of environmental conservation. The combination of satellite observations, GIS, remote sensing, and AI allows environmental information to be collected and analysed over large areas. AI-based approaches are increasingly being used to extract useful information from satellite and remote-sensing datasets, including land-cover changes, environmental degradation, and ecosystem conditions.

2.1 Forest and Deforestation Monitoring

Forests are important for biodiversity, carbon storage, water regulation, and climate stability. However, forest ecosystems are affected by deforestation, fires, land conversion, illegal activities, and climate-related disturbances. Monitoring these changes over large areas can be difficult through field surveys alone.

Satellite imagery provides repeated observations of forested regions, making it possible to compare vegetation and land-cover conditions over time. AI techniques can further assist by identifying changes in satellite images and distinguishing forested areas from agricultural land, settlements, or degraded regions. Machine learning has been increasingly applied to forest monitoring, including deforestation detection, forest health assessment, biodiversity analysis, and disturbance detection.

The use of multiple types of remote-sensing data can improve this process. Optical imagery can provide information about vegetation and land cover, while radar and LiDAR data can provide additional information about vegetation structure. Recent research on tropical forest recovery has highlighted the value of combining different sensors to obtain a more complete understanding of forest structure and recovery.

Such systems can support conservation authorities by identifying areas experiencing rapid changes and helping them prioritize field inspections. They can also be useful for evaluating the progress of reforestation and ecosystem restoration programmes.

2.2 Biodiversity and Wildlife Conservation

Biodiversity monitoring traditionally depends heavily on field observations, which can require considerable time, manpower, and financial resources. Remote sensing and AI provide additional ways to observe habitats and ecological changes over larger areas.

Geospatial information can be used to map habitat extent, vegetation characteristics, landscape fragmentation, and other environmental factors associated with biodiversity. AI can then assist in identifying patterns within these datasets. For example, image-based models can be trained to recognize species or ecological features from photographs and aerial imagery.

The combination of drones and deep learning is becoming particularly relevant for biodiversity monitoring. Recent research has examined the use of unmanned aerial vehicles with deep learning for species identification and ecological feature extraction, while also highlighting the importance of efficient and interpretable systems.

This approach can be useful in protected areas and difficult-to-access environments. Instead of replacing field-based ecological research, AI-supported geospatial monitoring can complement it by providing wider spatial coverage and helping researchers decide where detailed field observations are most needed.

2.3 Water Resource Monitoring

Water resources are affected by pollution, changing rainfall patterns, agricultural activities, urban development, and climate change. Monitoring rivers, lakes, wetlands, reservoirs, and coastal waters requires observations that can be collected repeatedly over time.Remote sensing can provide information about water extent, vegetation around water bodies, and visible changes in environmental conditions. When combined with GIS, these observations can be compared with other spatial information such as land use, rainfall, population distribution, and drainage networks.

AI can assist in identifying patterns within these datasets. Machine learning methods can be used for classification, change detection, and prediction, while image-based deep learning can support automated interpretation of satellite imagery. More broadly, reviews of AI-based environmental monitoring show applications involving water-related environmental impacts and the analysis of heterogeneous remote-sensing datasets.

Such systems can support water-resource managers by identifying areas that require closer investigation and by providing information for long-term resource planning.

2.4 Land and Ecosystem Management

Changes in land use are closely connected with environmental degradation. Expansion of cities, agricultural development, mining, and infrastructure can alter natural ecosystems and increase pressure on land resources.

Geospatial analysis can represent these changes through different spatial layers. AI can then help classify land-cover categories and identify changes between different periods. This is particularly useful when analysing large satellite archives, where manual interpretation would require considerable effort.

AI-based environmental monitoring has already been applied to land-use and land-cover change detection and other forms of environmental impact assessment.

The resulting information can support decisions about protected areas, restoration zones, agricultural planning, and sustainable land use. However, local environmental knowledge and field verification remain important because satellite-based classifications may not always capture the full ecological condition of an area.

2.5 Pollution and Environmental Monitoring

Pollution can vary considerably across space and time. Air pollution, waste accumulation, industrial activity, and changes in water quality can therefore benefit from spatial monitoring.

Geospatial systems can combine information from sensors, satellite observations, environmental databases, and geographic locations. AI can assist in identifying relationships between these datasets and detecting unusual patterns. Such systems may help locate pollution hotspots and identify regions where further investigation is required.

The use of AI and data fusion for environmental monitoring has expanded partly because multiple sources of environmental information can be combined and analysed together. This creates opportunities for more continuous environmental assessment rather than relying only on occasional surveys.

3. Green Geospatial Intelligence for Climate Resilience

Climate resilience involves the ability of communities, ecosystems, and infrastructure to prepare for, respond to, and recover from climate-related hazards. Geospatial technologies

can contribute to this process by showing where hazards occur and which areas or populations may be particularly exposed.

AI adds predictive and analytical capabilities to geospatial information. Instead of only mapping an existing hazard, AI models can analyse historical and current data to identify patterns associated with future risks. The combination of these technologies is particularly relevant to floods, droughts, wildfires, landslides, and coastal hazards.

3.1 Flood Risk Assessment

Flooding is influenced by several factors, including rainfall, elevation, drainage, soil conditions, land cover, and the characteristics of nearby water bodies. These factors can be represented geographically and analysed together. GIS can be used to create flood-risk maps by combining different spatial layers. Machine learning can further identify relationships between environmental variables and historical flood events. This can help distinguish areas with relatively higher levels of flood exposure.

The integration of remote sensing, GIS, and AI is increasingly being examined for natural-hazard assessment and resilience planning. Such approaches can provide useful information for emergency planning, infrastructure development, and early-warning systems.

3.2 Drought Monitoring

Drought develops over time and can affect vegetation, agriculture, water availability, and ecosystems. Detecting its progression requires information about environmental conditions across different periods.

Satellite observations can provide indicators related to vegetation and surface conditions. These observations can be combined with rainfall, temperature, soil, and hydrological information. AI can then be used to identify patterns associated with drought conditions and support monitoring over large regions.

The advantage of this approach is that environmental changes can be assessed repeatedly without requiring physical measurements at every location. However, ground observations remain important for validating satellite-based assessments and improving the reliability of AI models.

3.3 Wildfire Detection and Monitoring

Wildfires can rapidly damage forests, wildlife habitats, agricultural areas, and nearby communities. Early identification and continuous monitoring are therefore important for reducing their impact.

Satellite and aerial imagery can provide information about fire-affected areas and changes in vegetation. AI-based computer vision methods can analyse these images to detect fire-related patterns and map burned areas. Recent research examining GeoAI for wildfire science shows extensive use of remote sensing, GIS, and machine learning for wildfire detection, burned-area mapping, and susceptibility assessment.

Future systems could combine satellite observations, weather information, ground sensors, and AI models to support more comprehensive wildfire monitoring.

3.4 Landslide Risk Assessment

Landslides can occur when factors such as rainfall, slope, soil conditions, geological characteristics, and changes in land cover interact. Identifying areas with greater susceptibility can help improve .

preparedness.Geospatial datasets allow these factors to be represented spatially. Machine learning models can then analyse historical landslide information along with environmental variables to identify patterns associated with landslide occurrence.

Such models should not be treated as perfect predictions. Environmental conditions can vary considerably between locations, and therefore regional validation is necessary before an AI-based risk assessment is used for practical decision-making.

3.5 Coastal and Urban Climate Risk

Coastal regions face several interconnected pressures, including erosion, flooding, sea-level changes, and increasing human development. Similarly, cities can experience heat stress, flooding, and changes in local environmental conditions.

Satellite imagery and GIS can help identify vulnerable coastal and urban areas. AI can analyse historical spatial patterns and support risk assessment. In urban areas, geospatial information can also be used to study vegetation distribution, built-up areas, surface temperatures, and other factors associated with environmental vulnerability.

The broader climate-resilience perspective requires these technological assessments to be connected with planning, infrastructure development, ecosystem protection, and community needs rather than being treated as purely technical exercises

4. Green Computing Perspective

The environmental purpose of an AI-based system does not automatically make the system sustainable. AI applications require hardware, electricity, data storage, networking, and computational resources. This creates an important connection between environmental intelligence and green computing.

When large remote-sensing datasets are processed using complex deep learning models, computational requirements can become significant. Research on AI-based environmental monitoring has identified the need for appropriate computing resources and efficient algorithms when handling large remote-sensing datasets.

4.1 Energy-Efficient AI

Energy efficiency can be considered during model selection and development. A highly complex model is not always necessary for every environmental application. Smaller models, optimized architectures, transfer learning, and appropriate preprocessing can sometimes provide useful results with fewer computational requirements.

This is particularly relevant for environmental monitoring systems that need to operate continuously or in locations where computing resources are limited.

4.2 Efficient Geospatial Data Processing

Satellite imagery can contain large amounts of information, and processing every available image at maximum resolution may not always be necessary. Selecting relevant spatial and temporal data can reduce storage and processing requirements.

Data preprocessing can also remove irrelevant information, reduce redundancy, and prepare datasets for more efficient analysis. Data fusion can be useful when information from multiple sensors needs to be combined, although the additional processing requirements should also be considered.

4.3 Cloud and Edge Computing

Cloud computing provides access to scalable storage and processing facilities, which is useful for large environmental datasets. It can allow organizations to process data without maintaining all infrastructure locally.Edge computing takes a different approach by processing some information closer to where it is generated. For example, an environmental sensor or drone could perform initial processing and transmit only relevant information. This can reduce data transfer and support applications where rapid responses are important.

4.4 Sustainable AI Lifecycle

Sustainable AI should be considered across the entire lifecycle of a system. This includes data collection, model development, training, deployment, maintenance, hardware use, and eventual replacement. Therefore, environmental impact should not be evaluated only by looking at what an AI system achieves. The resources consumed in producing that result also matter. This broader perspective is important when designing Green Geospatial Intelligence systems.

5. Challenges and Limitations

Despite its potential, Green Geospatial Intelligence faces several technical, environmental, and practical challenges.

5.1 Data Quality and Availability

AI systems are highly dependent on the data used for training and testing. Environmental datasets may contain missing observations, inconsistent measurements, cloud-covered satellite images, geographical biases, or limited ground-truth information. A model trained using data from one geographical region may not perform equally well in another region with different environmental conditions. Recent research on data-driven geospatial modelling has identified challenges involving data quality, uncertainty, and the transferability of models across environmental contexts.

5.2 Computational Cost

High-resolution imagery and complex deep learning models can require considerable computational resources. This creates a potential conflict with the sustainability goals of Green Geospatial Intelligence. Model optimization and energy-aware computing should therefore be considered during system development. The objective should be to obtain useful environmental information without using significantly more computational resources than necessary.

5.3 Model Accuracy and Generalization

AI models can produce incorrect classifications or predictions. Environmental systems are particularly challenging because natural conditions change continuously and may differ considerably between locations. For this reason, AI outputs should be validated using appropriate field observations or

independent datasets. A model should not be considered reliable simply because it performs well on its original test dataset.

5.4 Explainability and Trust

Some advanced AI models can be difficult to interpret. This can become a concern when their outputs influence environmental policies or decisions involving communities and natural resources. Explainable AI can help users understand which factors contributed to a model's prediction. Greater transparency can make environmental AI systems easier to evaluate and improve confidence in their results.

5.5 Data Privacy and Ownership

Geospatial information can sometimes contain sensitive information about private property, infrastructure, communities, or specific locations. Data-sharing practices therefore need to consider privacy, ownership, security, and responsible access.

5.6 Infrastructure and Skill Requirements

Advanced geospatial AI systems require suitable hardware, software, data access, and technical expertise. These resources may not be equally available in all regions, particularly in areas where environmental monitoring is most needed.

Consequently, future systems should focus not only on technological sophistication but also on affordability, accessibility, training, and local participation

6. Future Directions

6.1 Green AI for Geospatial Applications

Future research can focus on AI models that achieve a suitable balance between accuracy and computational efficiency. Instead of measuring success only through prediction accuracy, researchers can also consider energy use, processing time, model size, and hardware requirements.

6.2 Multi-Sensor Environmental Intelligence

Future environmental monitoring is likely to make greater use of multiple forms of Earth observation. Optical, radar, LiDAR, thermal, drone, and ground-sensor data can provide different types of information about an ecosystem.

Recent research has emphasized the value of multi-sensor integration for monitoring terrestrial ecosystems and forest recovery. Combining these sources can provide a more complete picture than relying on a single type of observation.

6.3 Edge AI for Real-Time Monitoring

Edge AI could become increasingly useful in remote environmental monitoring. Sensors and drones may be able to process selected data locally and communicate only important information to central systems. This could be valuable for applications such as wildfire monitoring, wildlife observation, agricultural monitoring, and water-quality assessment, where rapid processing may be more useful than transferring every piece of collected data.

6.4 Digital Twins for Ecosystem Management

Digital twins can be used to create dynamic digital representations of physical systems. In environmental applications, a digital representation could combine spatial data, sensor observations, historical information, and AI models.

For example, a digital representation of a forest could incorporate information about vegetation, temperature, rainfall, soil, and disturbance history. Researchers could then use the system to explore possible environmental scenarios and support conservation planning.

6.5 Advanced AI and Earth Observation

The development of more capable AI models is likely to expand the analysis of Earth-observation data. Recent research already points towards growing use of advanced approaches such as transformers, graph neural networks, and self-supervised learning in biodiversity monitoring.

However, greater model complexity should not automatically be treated as progress. Future research should balance improved analytical capability with transparency, computational efficiency, and environmental cost.

6.6 Human-Centred Environmental Intelligence

Technology should support environmental experts and communities rather than completely replace human judgement. Local ecological knowledge can provide information that may not be visible in satellite images or sensor datasets.

A future Green Geospatial Intelligence system could therefore combine AI-generated insights with scientific expertise, field observations, and local knowledge. This would create a more balanced approach to environmental decision-making.

7. Conclusion

Green Geospatial Intelligence provides an interdisciplinary approach to environmental conservation by combining Artificial Intelligence, GIS, remote sensing, Earth observation, and sustainable computing. These technologies can transform large amounts of environmental data into useful information for ecosystem monitoring and conservation decisions.

Its applications include forest monitoring, biodiversity assessment, water-resource management, land-use analysis, pollution monitoring, and natural-hazard assessment. They can also support climate resilience through flood-risk assessment, drought monitoring, wildfire detection, landslide analysis, and identification of vulnerable coastal and urban areas.

However, challenges such as poor-quality data, regional differences, computational costs, uncertainty, limited infrastructure, and lack of transparency can affect the effectiveness of AI-based systems. Therefore, successful environmental intelligence requires reliable data, proper validation, efficient computing, and collaboration among researchers, policymakers, and local communities.

Ultimately, Green Geospatial Intelligence should not be judged only by analytical accuracy, but by its contribution to ecosystem protection, climate resilience, and sustainable development. With responsible design and human oversight, it can play an important role in building a more resilient and sustainable future.

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Traditional Medicine and Wellness

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Abstract: Health systems around the world are experiencing increased levels of chronic illness, population aging and escalating health care costs. Patients and health care providers alike are demanding that health care services be revitalized, with a stronger emphasis on individualized, person-centred care. This includes expanding access to traditional and complementary medicine products, practices and practsitioners, in particular in primary health care. India is known for its traditional medicinal systems Ayurveda, Siddha, and Unani. Medical systems are found mentioned even in the ancient Vedas and other scriptures. The Ayurvedic concept appeared and developed between 2500 and 500 BC in India. India is the largest producer of medicinal plants. There are currently about 250,000 registered medical practitioners of the Ayurvedic system, as compared to about 700,000 of the modern medicine. In India, around 20,000 medicinal plants have been recorded; however, traditional practitioners use only 7,000–7,500 plants for curing different diseases. The proportion of use of plants in the different Indian systems of medicine is Ayurveda 2000, Siddha 1300, Unani 1000, Homeopathy 800, Tibetan 500, Modern 200, and folk 4500. The pharmacological treatment of disease began long ago with the use of herbs. Traditional Chinese medicine has been used by Chinese people from ancient times. Although animal and mineral materials have been used, the primary source of remedies is botanical. Of the more than 12 000 items used by traditional healers, about 500 are in common use. Medicinal natural products must also be consumed with care and preferably after consultation with a healthcare provider, as some of them are known to cause serious side effects including drug–drug and drug–food interactions. More clinical trials are warranted to determine the effectiveness of various natural products and capitalize their substantial potential against many diseases.
Keywords: Health systems, Chronic illness, Diseases, Natural products, Traditional medicinal systems.

Introduction

Health systems around the world are experiencing increased levels of chronic illness, population aging and rising health care costs. Patients and health care providers alike are demanding that health care services be revitalized, with a stronger emphasis on individualized, person-centred care. Traditional medicine is often seen as more accessible, more affordable, and more acceptable to local populations and can therefore be a tool to help achieve universal health coverage. Traditional medicine is commonly used in large parts of Africa, Asia and Latin America. For many millions of people, often living in rural areas in developing countries, herbal medicines, traditional treatments and traditional practitioners are the main, sometimes the only, source of health care. In wealthy countries, traditional medicine meets an additional set of needs. People want natural products and want to have more control over their health. India is known for its traditional medicinal systems Ayurveda, Siddha, and Unani. Medical systems are found mentioned even in the ancient Vedas and other scriptures. The Ayurvedic concept appeared and developed between 2500 and 500 BC in India[1-3].

Traditional Medicines

Alternative medicines are being used by about 60 percent of the world's population. These medicines are not only used by the rural masses for their primary health care in developing countries but are also used in developed countries where modern medicines dominate.

The Indian subcontinent is a vast repository of medicinal plants that are used in traditional medical treatments. The alternative medicines in the traditional systems are derived from herbs, minerals, and organic matter, while for the preparation of herbal drugs only medicinal plants are used.

Use of plants as a source of medicine has been an ancient practice and is an important component of the health care system in India. In India, about 70 percent of rural population depends on the traditional Ayurvedic system of medicine. Most healers/practitioners of the traditional systems of medicine prepare formulations by their own recipes and dispense to the patients. In the Western countries, approximately 40 per cent of people are using the herbal medicine for the treatment of various diseases[4-8].

This interest in traditional medicines is growing rapidly due to the attention being given to it by the governmental agencies and different NGO's comprising of general public and researchers as well as the increased side effects, adverse drug reactions, and cost factor of the modern medicines.

India is the largest producer of medicinal plants. There are currently about 250,000 registered medical practitioners of the Ayurvedic system, as compared to about 700,000 of the modern medicine. In India, around 20,000 medicinal plants have been recorded; however, traditional practitioners use only 7,000–7,500 plants for curing different diseases. The proportion of use of plants in the different Indian systems of medicine is Ayurveda 2000, Siddha 1300, Unani 1000, Homeopathy 800, Tibetan 500, Modern 200, and folk 4500. In India, around 25,000 effective plant-based formulations are used in traditional and folk medicine. More than 1.5 million practitioners are using the traditional medicinal system for health care in India. It is estimated that more than 7800 manufacturing units are involved in the production of natural health products and traditional plant-based formulations in India, which requires more than 2000 tons of medicinal plant raw material annually. More than 1500 herbals are sold as dietary supplements or ethnic traditional medicines.

Some common medicinal plants having nutraceutical potential and their primary use in traditional medicine[9-15]:

Plant name	Common name	Uses
Asparagus racemosus Willd	Shatavari	It also helps to maintain urinary tract and strengthens the immune system and also purifies the blood.
Commiphora mukul Engl.	Guggul	It also protects against the common cold as well as used in various other conditions like lower cholesterol and triglycerides, while maintaining the HDL to LDL ratio.
Cyperus scariosus Br.	Nagarmusta	Useful in supporting healthy genitourinary system and have hepatoprotective properties.
Garcinia cambogia Dr	Garcinia	Garcinia contains significant amounts of vitamin C and used as a heart tonic.
Glycyrrhiza glabra L.	Yashtimadhu, Licorice	It is a versatile medicine in India and China, for gastrointestinal health. It is a mild laxative, soothes and tones the mucous membranes, and relieves muscle spasms.
Gymnema sylvestre R. Br.	Gurmarar	It has been used in Ayurveda to regulate sugar metabolism for several centuries. It increases

Plant name	Common name	Uses
		insulin production, regeneration of pancreas cells, and the site of insulin production.
Melia azadirachta L.	Nimba, Neem	It has shown most beneficial effects for the circulatory, digestive, respiratory, and urinary systems.
Momordica charantia L.	Karela, Bitter melon	It contains Gurmarin, a polypeptide considered to be similar to bovine insulin, and has a strong sugar regulating effect by suppressing the neural responses to sweet taste stimuli.
Moringa pterygosperma Gaertn	Shigru, Horseradish tree	Shigru contains physiologically active principles that is effective in a broad range of health needs. It contains "Pterygospermin," an antibiotic-like substance.
Mucuna pruriens Baker	Kiwanch, Kapikachchhu, Cow-itch plant	It is a good natural source of L. dopa. In the Ayurvedic system it is reported as an effective tonic for nervous system.
Nardostachys jatamansi DC.	Jatamansi, Musk root	It has been shown effective in maintaining a restful sleep and with many menopausal symptoms.
Piper longum L.	Pippali, Indian Long Pepper	Pippali is a powerful stimulant for both the digestive and the respiratory systems and has a rejuvenating effect on lungs.
Piper nigrum L.	Maricha, Black pepper	It is used to amplify the body's ability to absorb nutrients contained in the food and aid the digestive process.
Bergenia ligulata Wall	Pasanavheda	It has the unique property like diuretic action with optimum urinary tract health.
Terminalia chebula Retz.	Haritaki	It is known to have strong antimutagenic activity, because of its very rich content vitamin C.
Tinospora cordifolia Miers	Guduchi	Use of this plant increases white blood cells the killing ability of macrophages, the immune cells responsible for fighting invaders.
Withania somnifera (L.) Dunal	Ashwagandha	It is one of the best health tonics and restorative agents that have been used to treat general debility.
Zingiber officinale Rosc	Sunthi, Ginger	Ginger is considered an adjuvant in many Ayurvedic formulas in which it enhances absorption and prevents gastrointestinal side effects.

Herbal Medicines in Dietary Supplements

Dietary supplements and herbal remedies are popular complementary or alternative products for people. These are the supplements that are intended to supplement the diet and contain one or more dietary ingredients (including vitamins, minerals, herbs or other botanicals, amino acids, and other substances) or their constituents. These are intended to be taken by mouth as a pill, capsule, tablet, or liquid and are labeled on the front panel as being a dietary supplement. Such products may range from isolated nutrients, dietary supplements, and diets to genetically engineered "designer" foods, herbal products, and processed foods such as cereals, soups, and beverages. These botanicals are sold in many forms as fresh or dried products, liquid or solid extracts, tablets, capsules, powders, tea bags, and so forth[16].

The role of herbal medicines in traditional healing

Traditional Chinese medicine

Traditional Chinese medicine has been used by Chinese people from ancient times. Although animal and mineral materials have been used, the primary source of remedies is botanical. Of the more than 12 000 items used by traditional healers, about 500 are in common use. Botanical products are used only after some kind of processing, which may include, for example, stir-frying or soaking in vinegar or wine. In clinical practice, traditional diagnosis may be followed by the prescription of a complex and often individualized remedy.

Japanese traditional medicine

Many herbal remedies found their way from China into the Japanese systems of traditional healing. Herbs native to Japan were classified in the first pharmacopoeia of Japanese traditional medicine in the ninth century.

Indian traditional medicine

Ayurveda is a medical system primarily practised in India that has been known for nearly 5000 years. It includes diet and herbal remedies, while emphasizing the body, mind and spirit in disease prevention and treatment.

Medicinal applications, beneficial effects and active components

In some cases, the active principles of plant-derived products have been isolated and characterized, and their mechanisms of action are understood (e.g., ephedrine alkaloids in some species of Ephedra). For many, however, including virtually all of the most common products in the marketplace, such information is incomplete or unavailable. This is in large part due to the complexity of herbal and botanical preparations; they are not pure compounds.

WHO guidelines for herbal medicines

A few herbal medicines have withstood scientific testing, but others are used simply for traditional reasons to protect, restore, or improve health. Most herbal medicines still need to be studied scientifically, although the experience obtained from their traditional use over the years should not be ignored. As there is not enough evidence produced by common scientific approaches to answer questions of safety and efficacy about most of the herbal medicines now in use, the rational use and further development of herbal medicines will be supported by further appropriate scientific studies of these products, and thus the development of criteria for such studies'.

The document covered such topics as developing protocols for clinical trials using herbal medicines, evaluating herbal medicine research, guidelines for quality specifications of plant materials and preparations, and guidelines for pharmacodynamic and general pharmacological studies of herbal medicines and for toxicity investigations of herbal medicines[17-18].

WHO has also issued Guidelines for the Assessment of Herbal Medicines. These guidelines defined the basic criteria for the evaluation of quality, safety and efficacy of herbal medicines with the goal of assisting national regulatory authorities, scientific organizations and manufacturers in assessing documentation,

submissions and dossiers in respect of such products. It was recommended that such assessments take into account long-term use in the country (over at least several decades), any description in the medical and pharmaceutical literature or similar sources or documentation of knowledge on the application of a herbal medicine, and marketing authorizations for similar products. Although prolonged and apparently uneventful use of a substance usually offers testimony of its safety, investigation of the potential toxicity of naturally occurring substances may reveal previously unsuspected problems. It was also recommended that regulatory authorities have the authority to respond promptly to new information on toxicity by withdrawing or limiting the licences of registered products containing suspect substances, or by reclassifying the substances to limit their use to medical prescription.

Traditional Indian Medicine

Ayurveda

Traditional Indian medicine has been in existence since antiquity and is inarguably among the most ancient systems of traditional medicine still in existence. Clinical trials, teachings, and writings related to Ayurveda have played a tremendous role in popularizing it. Some of the most prominent Westerners who have helped make the system known worldwide include David Frawley and Robert Svoboda, whose works have had an immense effect on the knowledge of the system. The relevance of Ayurveda in the modern world remains as it was since the commencement of printing of the protagonist classic texts that were compiled in the fifth and sixth centuries.

The Ayurveda system holds that the whole universe consists of five main elements, being Vayu (air), Jala (Water), Aakash (space or ether), Prithvi (earth), and Teja (fire). The latter (referred to as Pancha Mahabhoota in Ayurveda) is composed of three vital body humors in different amounts. The three humors are collectively referred to as "Tridoshas," including Vata dosha, Pitta dosha, and Kapha dosha. Each of the elements contain five sub-doshas that control the most important physiological functions of the body. According to this system, the human body contains Saptadhatus (seven tissues), Rakta (blood), Rasa (tissue fluids), Meda (fat and connective tissue), Asthi (bones), Mamsa (muscle), Majja (marrow), Shukra (semen) and three Malas (waste products) of the body, viz. Purusha (feces), Mutra (urine), and Sweda (sweat). The Vata dosha oversees the body's electrolyte balance, transport of cellular components, and getting rid of waste products. Its effects on the body are resonated by dryness. The different tissues interact with one another to maintain the normal physiological functioning of the body. The blood circulation and production of the important blood components in the body are performed by the Rakta Dhatu. On the other hand, the Mamsa Dhatu (Muscle tissue) maintains the support of the skeletal muscles for the adipose tissue (Meda Dhatu). The bones are made up by the Asthi Dhatu, while the Majja Dhatu consists of the fluids that oleate the bones and the bone marrow. The Shukra Dhatu controls the reproductive functions of the body.

The Pitta dosha regulates the body temperature, thirst, hunger, and coordination of the optic nerves. The Kapha dosha is affected by fatty and sweet foods; it enables the lubrication of the body's joints for proper coordination. It is believed that the Vata controls the body's catabolism; the Kapha oversees the metabolism, while the Kapha controls the anabolism of the body. For the body to maintain a healthy state, the three doshas and other related factors and their interactions must have a balance.

Siddha System

The system provides rejuvenating, rehabilitative, promotive, and preventive care through a holistic and scientific approach. Siddha is rooted in "Citti," which means achieving accomplishment, internal bliss, and perfection. The system entails philosophical concepts with four components: medical practice, yogic practice, iatrochemistry, and wisdom. These revolve around the intellectual, psychological, physical, and physiological aspects of all human beings.

The Siddha system include theories of five elements (Aimpootham) that constitute the universe (in terms of properties), three forces/faults (Mukkuttram) that help maintaining homeostasis, and eight methods of examination (Envakai Thervukal) that help in proper diagnosis and treatment. The body's physical components identified by this system are also highlighted in the Ayurveda system. The pathological and physiological aspects of these components have been described in the literature of this system and heavily relied upon in practice. The cornerstone of the treatment of Siddha is based on a holistic approach[19].

Unani System

Unani is also known as Unani Tibb and is believed to have originated from Greece; its doctrines have been found in the writings of the ancient Greek physicians Galen and Hippocrates. The system was refined and developed with time through experimentation by the Arabs and was made prominent by the Muslim teacher Avicenna. Part of the medicine's principles was adopted from this system during the Muslim political-religious regime in 632 CE. This system has been established through contributions from the Middle East and South Asia; it has become acceptable in different parts of the globe. Healing from the system relies upon principles of balance and harmony that include uniting the spiritual, mental, and physical realms together.

The system holds that the health of the body is maintained by the orderly arrangement of the seven vital physiological principles as stated by the Unani doctrine. These principles are arkan (elements), mizaj (temperament), akhlat (bodily humors), aaza (organs and systems), arwah (vital spirit), afaal (functions), and quwa (faculties or powers). All these components interact with one another to maintain the balance of the normal and natural makeup of the human body. Every human constitution has the capacity and power to regulate itself and maintain the seven components' equilibrium.

There are four entities, thenar (fire), arz (earth), Hawa (air), and maa (water), that make up the basic components of the body and the entire creations of the Earth. The four entities can interact to create consequences that are predictable by man. The elements act upon and rely on each other; they continuously change deterioration and generation due to the body's reaction to the medicines administered[20].

Homeopathy

The renowned Dr. Samuel Hahnemann is the protagonist of this system, who popularized it in the mid 17 and 18 centuries. The basic principle of this system is, "like can cure like." If a substance can elicit symptoms in the human body, it can also cure the same symptoms in sick people. The principle has been around for some time, but it was until 200 years ago that it was applied in medicine. Hahnemann believed that the correct and accurate remedy presented the body's vital force with mild disease. For instance, if the disease itself is so strong, it overwhelms the ability of the vital force of the body to correct it. The used substances to treat the initial infections are gentle so that it mounts a response that can correct the imbalance existing in the body due to the disease. Since the symptoms produced by the disease are similar to those induced by the medical disease, the body's responses can lead to healing[21].

Yoga

Yoga has become popular in all parts of the world in recent decades. The practice dates to antiquity and has been established as useful to establish physical and spiritual balance in the body. The relevance of yoga in health care has increased as more attention has been paid to the practice. Published reports have indicated that yoga has helped many master the challenges in their lives and to develop confidence and control of their lives. The roots of yoga trace back to ancient India. In describing the meaning of the word yoga, union, mastery, and control are of particular importance. Cultural and individual factors influence the practice of yoga[22].

Naturopathy

Naturopathy is a healing system that utilizes natural remedies to treat diseases and illnesses. It entails different methods like nutritional counseling, herbs, massage therapy, exercising, and acupuncture to solve health problems. The major objective of this therapy is to bring healing to the entire persona. This includes

the spirit of the person, mind, and body. Additionally, the ultimate goal is to cure the base issue or the root cause of the illness and not only the presenting symptoms. The expert takes about an hour or two to examine the patient before identifying the treatment remedy. The patient may be questioned on their entire health history, lifestyle patterns, quantum, and any reason that may lead to the acquisition of an illness[23-24].

Conclusion

Plants, herbs, and ethnobotanicals have been used since the early days of humankind and are still used throughout the world for health promotion and treatment of disease. Plants and natural sources form the basis of today's modern medicine and contribute largely to the commercial drug preparations manufactured today. The use of traditional medicine and herbs to optimize the immune system is something that needs to be explored further to bring effective and sustainable therapeutic products into the market quicker. Natural products have a demonstrated history of use in a spectrum of health conditions, owing to a variety of potent immunomodulatory, anti-inflammatory, and antiviral properties[25-26]. Consuming many of the natural supplements (pure and safe amounts) has shown to decrease susceptibility to viral infections, subsequently improving the clinical outcomes. Medicinal natural products must also be consumed with care and preferably after consultation with a healthcare provider, as some of them are known to cause serious side effects including drug–drug and drug–food interactions. More clinical trials are warranted to determine the effectiveness of various natural products and capitalize their substantial potential against many diseases.

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LEARNING TO HUNT THROUGH BOARD GAMES

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Abstract: Very little is known about the board games of South American indigenous peoples. This lack of information and/or dissemination regarding indigenous games and toys can be attributed to the disinterest that the subject elicited for years among anthropologists and archaeologists, who defined them as ritual objects (Langley and Lister, 2018).

Despite this, records have gradually been recovered through systematic bibliographic and field research to highlight and bring to light the ancestral playful culture of these peoples. This work led to the discovery of several games, some of which are board games, which are the subject of this article.

Introduction:

The board games played by various South American indigenous peoples described here depict a confrontation between a hunter aided by dogs and a puma. Their widespread presence across part of the continent raises the question of whether their origins are very ancient and whether they have been passed down from generation to generation, taking on different forms of play because their rules were transmitted orally.

Their description allows us, in agreement with Magrassi (1985), to analyze the possibility that this game evolved from a method of teaching 9-year-old boys the technique of hunting by cornering animals, which, with social evolution, transformed into a game for entertainment. Another detail noted by the researcher is that the activity was practiced exclusively by boys. The practice by girls has been documented as a game since the 1980s.

Development:

The Hunting System

To connect Magrassi's observations regarding the possible origin of this game, the following is a transcription of the explanations about hunting provided by Pati (an elderly woman from the Tehuelche people, who are of hunter-gatherer origin) to researcher Aguerre in 2000.

Pati says:

We'd go out on foot to hunt guanacos (…), we'd all go out hunting; we kids were the ones who scared the guanacos (..)… How did we hunt them?... We'd corner them, or all the kids would form a circle around them—we'd form a circle and drive them in… the older ones were the ones who drove them in. The guanacos would be cornered, and we'd act as a sort of corral to keep them from getting through… There were so many of us that, between our shouts and the fences, we'd corral any number of them. (…) … many say… "Nooo!" … "How can you hunt them… you have to be in a big group or have lots of dogs" (in Aguerre, 2000, p. 122).

The guanaco was hunted for food and as a source of material for making their mobile homes and clothing. "To hunt the lion, a spear is used (…) The long ones are for killing from horseback… so that the lion won't reach you with a swipe of its paw" (p. 123). The "lion" refers to the puma, since there are no lions in the Americas (this error originated with Spanish travelers).

In addition, the presence of the dog as a human companion in the game may be a modern representation of a joint activity for which there is evidence dating back to around 8,000 BCE. González Venanci (et al., 2025) note that "in historical times, dogs were recorded as being used as pack animals, hunting assistants, and guardians."

González (1910) describes how selknam parents, from the moment a boy is born, craft small bows and arrows for him so that he may become a skilled hunter.

When considering the relationship between play and hunting systems, it is worth examining Gross's (2007) theory, which states that play is a means of learning for adult life. This raises the question: Was this play originally a way of teaching hunting strategies, and did it evolve into a purely recreational activity as society developed?

Hunting Games of South American Indigenous Peoples.

The Lioness

This game was discovered by Dr. Gambier (1981); it was played by elders in the area around the town of Albardón in the Argentine province of San Juan. In a conversation with the locals, they explained that they had been playing it since childhood, which led us to conclude that it has been passed down through generations since ancient times, given that the population in the area is indigenous.

To play, the game board is drawn on the ground. The piece representing the lioness is placed at the top of the triangle, and the 12 dogs are positioned as shown in Photo No. 1.

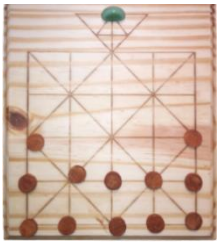


Photo No. 1: Recreation of the game the lioness (MJE). Photo by the author

Objective: The dogs try to surround the lioness to win the game; the lioness, on the other hand, tries to eat three dogs to win. Some villagers explain this way of playing, noting that with nine dogs, it is impossible to catch the lioness. Other villagers, however, play until the lioness eats all the dogs and wins.

How to play: The lioness starts the game. The first three moves can only be made forward or to the side; starting with the fourth move, all pieces can move in any direction, always alternating turns between the lioness and the dogs and always moving along the lines to land on an intersection.

The lioness "eats" a dog by jumping over it if there is an empty space immediately next to it, while the dogs will always try to trap her in a section of the board so she cannot advance.

La Yagua or The Tiger and the Dogs

A game discovered by Magrassi (1985) among the chiriguano-chané and guaraní peoples living in the Argentine province of Misiones. The researcher notes that some groups called it "The tiger and the dogs," but in 2009, professor and researcher Rodas stated that he knew it as "la yagua."

In this regard, Magrassi says:

In the past, it may have been part of how young boys learned the role of a hunter. It is not played for or because of anything in particular, but for the simple pleasure of playing, demonstrating skills in control, thinking, memory, and concentration. It is a debate, a contest or struggle, a competition in which the key is precision in control (1985, p. 4).

Just like in the game "la leonessa," the board is drawn on the ground; it also has the same board design and arrangement of pieces. There are two players who take on different roles: one is the yagua (puma or American tiger) and the other is the dogs, which are called yamba.
Objective: The yambas try to trap the yagua by immobilizing it in order to win the game, while the yagua tries to eat the dogs to win.
How to Play: The yagua starts the game; the pieces are moved in alternating turns. Magrassi explains that "at the start of the game, moves are always forward or to the sides, but as the game progresses, the pieces can also move backward, always along the marked lines or paths" (1985, p. 4). The yagua eats by jumping onto a dog that is next to an empty space. The eaten yamba is then removed from the board. The game ends when the yagua is immobilized or when it has eaten three dogs. The author states that the player representing the dogs "can continue playing, but will invariably lose: with nine dogs or fewer, it is impossible to hunt a jaguar" (1985, p. 4). The rules of the game were always agreed upon before the game began.

Yaguareté Kora
This is a variation of the previous game that has recently been popularized by a group of young people from several communities in the Argentine province of Misiones, who call it yaguareté or korá, chivi kora (the jaguar's pen). The board is the same as in the two previous versions, but the number of dogs has increased to fifteen in this variation; they are placed in groups of five, starting from the edge of the board. The yaguareté is placed in the triangle that serves as its den.

Objective: The yaguareté wins if it captures the dogs, and the dogs win if they manage to surround and immobilize it to prevent it from capturing dogs or escaping.

How to play: The jaguar starts the game, followed by the dogs; turns alternate between the jaguar and the dogs. During the game, the jaguar can move in any direction, but the dogs cannot move backward. The dogs can enter the triangle to try to achieve their objective of trapping the jaguar.

Trapial Kuzen
In the Patagonian territories that became the provinces of Santa Cruz, Chubut, Río Negro, and Neuquén, there are records of this board game, played by the mapuche and the günün a kuna (or tehuelche), under the name trapial kuzen, or "the dogs and the lion." Two variations were documented by Martínez Crovetto in 1969, as detailed below:

Version 1:
Mr. Tomas (a günün a kuna or tehuelche) who lived in the area bordering the provinces of Chubut and Río Negro recounted that, in the past, it was also played by the araucanians (referring to the mapuche). The game had fallen out of use by that time, but he remembers it as a game from his childhood.
As in all previous cases, the board was drawn on the ground, and the design is similar, differing only in the pattern of the lines forming the smaller triangle. The placement of the trewas is also different (Photo No. 2). To play, 12 stones are used to represent the dogs (trewas) and one larger stone representing the lion or lioness (zomo trapial).
Objective: The zomo trapial's goal is to eat the trewas, while the trewas will try to trap it somewhere or in its lair.

How to Play: The zomo trapial starts the game and moves first; then a trewa moves, and so on. Moves can be made in any direction. The zomo trapial can eat a trewa only if there is an empty space immediately

adjacent to it. The zomo trapial wins the game when it manages to outmaneuver the trewas by reaching the end of the board, or by eating them all; however, if it is trapped by the Trewas anywhere on the board or in its own lair, it loses.

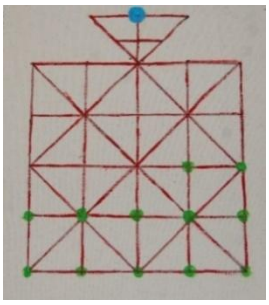


Photo No. 2 Reproduction of the board from Martínez Crovetto, 1969, p. 8,MJE (Photo by the author)

Version 2:
Mr. Cañicul, a resident of the mapuche community of the same name on Lake Huechulafquen in the province of Neuquén, explained that the board is drawn on the ground but its design differs from the previous ones. The game is played with 14 stones, which represent the dogs or trewa; these are placed in the large square, and the zomo trapial is placed in the small one, as shown in Photo No. 3.

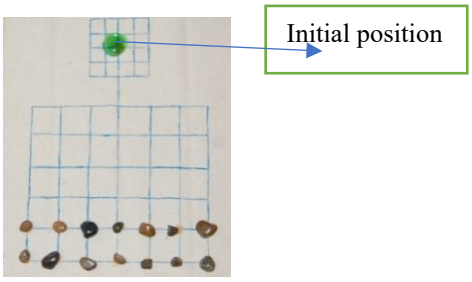


Photo No. 3. Reconstruction of Martínez Crovetto's drawing, 1969, p. 8 on canvas. (Photo by the author)

Objective: “The dogs’ goal is to trap the lion in its den or anywhere on the board and prevent it from moving at all, but they lose if the lion manages to cross its double line” (Crovetto, 1969, p. 8). The lion, on the other hand, aims to eat them.

How to Play: The game begins with the lion or lioness:

Pieces can be moved, one at a time, along horizontal or vertical lines and placed at their intersections (…) A piece moves one square to an adjacent square. The dogs and the lion can move forward, backward, or sideways. (…) The “trapial” can capture a “trewa” if it is not backed by another piece behind it, (…) and can remove an opposing piece by moving forward, backward, or sideways. When the lion devours a dog, it jumps over it and lands on the square behind it, depending on the direction from which it is coming (Crovetto, 1969, pp. 8–9).

The zomo trapial wins the game if it achieves either of its two objectives, but loses if the trewas achieve theirs.

Komikan chil
In the IX Region of Chile, when research was conducted in the late 1980s, this game was not

recalled by local residents, but it was possible to find a text by Manquilef (1914) in which he describes—under the names komikan chil, "the little lion," or "eat it all"—a board game similar to the ones mentioned above. The author explains that, in the past, this game served a moral purpose for his people. Likewise, as a recreational activity, he classifies it as part of domestic games with social and educational purposes (Ferrarese 1997).

Although he does not draw the board, his description has made it possible to reconstruct its design; and although he does not specify whether the triangle has lines inside it, the explanation of the arrangement of the stones—similar to that in the game the lioness—suggests that it is the same or that the differences are minimal.

Objective: The little dogs' mission is to trap the komikelu, and the komikelu's is to eat them" (Manquilef, 1914, (13) 87 and (31) 105).

How to Play: The game begins by moving the komikelu, followed by a puppy. Players always take turns moving one after the other, in any direction. The puppies will try to trap the komikelu somewhere on the board or in its den, while the komikelu tries to eat them—an action it can perform if there is an empty space adjacent to the puppy it wishes to eat.

Komikan

Matus (1920) discovered the game with this name among the mapuche people living in the city ofValdivia and says the following: "It is very well known among our children (…) the lines for playing a game are usually drawn on the ground (…) It is played with twelve small stones representing the dogs and one larger stone representing the lion" (1920, p. 10). Its layout differs from the game the lioness only in the dividing lines of the triangle (Photo No. 4).

Objective: As in all the previous games, the dogs will try to trap the komikan, and the komikan will try to eat them.

How to Play: The komikan starts the game. Then a dog makes a move, and so on:

The dogs are required to advance at all times and attempt to surround the lion by forming two lines. The lion can advance or retreat at any time and in any direction (…) Whenever the lion encounters a lone dog that is not protected by another, it eats it, pouncing on it and taking the vacant position. When it encounters two dogs with a single position between them, it can eat both. For their part, the dogs advance with great care and discipline, attempting to immobilize the lion (Matus, 1920, p. 10).

As in all the modes described above, the dogs win if they immobilize the komikan, and the komikan wins if it eats the dogs.

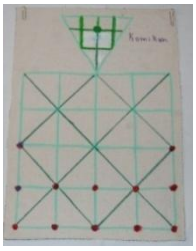


Photo No. 4: Reconstruction of the board (Matus, 1920, p. 10) MJE (Photo by the author).

Among the mapuche of the Argentine Patagonian region, the game was not known by this name but rather as “trapial kuzen.”
As in all previous cases, there are no records of women participating in this game, which links its practice to hunting—an activity that is generally male-dominated across all cultures.

The Taptana, or the Fox and the Sheep
The Bolivian-Peruvian Andean highlands constitute a sociogeographic area that has been in contact since approximately 15,000 BP, forming “an entire cultural unit of the Bolivian-Peruvian territory, both in space and over time” (Murra 1983 in Huarita 202, p. 51). This culture was built upon the relationship between humans and their environment, from which myths and games related to the agrarian world and its oracles have emerged.
Among these, the researcher found a game called chaku, or vicuña rodeo, which Garcilaso de la Vega recorded in 1609; this practice took place at a certain time of year, after the breeding season, in the presence of the Inca, and consisted of chasing vicuñas across a vast plain to catch them (they also used to catch other animals) (Huarita 2021). This playful activity is reminiscent of what Pati recounted to Aguerre (2000) regarding a game played by the tehuelche in Argentine Patagonia, which bears some resemblance to the game under study. This board game is similar to another one that Huarita found in the Usuma area, in the Department of Oruro, Bolivia, known as “taptana” or “the fox and the sheep”:

This behavior has been observed in September and October (the planting season for quinoa and potatoes), mainly on grazing lands in Qalaquta Ura, Kullcha, and Tara-tara Pampa in the lower Sayañas. At these sites, shepherds from various families drive their flocks out to graze, while their parents cultivate the land in the upper and middle sayañas. The Michiqkuna play “fox and sheep.” (…) (2021, p. 369).
The board's design is the same as that of **Version 1** (Photo No. 2). The larger square has sides measuring 40 cm and is attached to a triangle divided into four parts, but it differs from the Version 1 board in the number of pieces: here there are 15 haqhas (dung balls), which represent sheep or lambs and are placed in three groups of five starting from the opposite end within the square, just as in all the other games. Meanwhile, the other larger piece—or a stone—represents the fox within the triangle.

Objective: The fox must try to eat as many sheep as possible to win, but if the sheep manage to surround it anywhere within the larger square without letting it return to its hiding place, or if they manage to position themselves at the seven intersection points of its hiding place, preventing it from entering, they will be the winners.

How to Play: Similar to all the games described above.
Huarita (2021) identifies it as a game native to the Andean world that predates the arrival of European colonizers and has always been part of the agrarian worldview of the peoples who make up the societies of the Altiplano. In this regard, he states that this story, which has been passed down from generation to generation in the Andean world of the Bolivian-Peruvian Altiplano, attests to the game’s pre-Hispanic origin since, throughout that entire region—in both the games and the narrative— “agroecological indicators, the agricultural cycle, and festive rites converge in the representation of the fox as the sole element that recreates the life and agricultural cycles in the cultural life of these communities” (Huarita, 2021, p. 46).

La leonera
The only reference to this game, played in the Peruvian region that forms part of the Bolivian-Peruvian Altiplano or the Andean world, comes from the researcher Paz (in Solar and Hoisting, 2006), who states

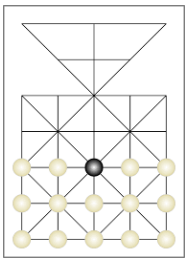
that he played la leonera in his childhood exactly as it is played today and with the same game board described by Huarita (2021), of which a dozen petroglyphs have been found to date (see Ferrarese 2025). Although Paz does not describe the game in its entirety, we agree with Huarita that it is the same game, given that it is part of the same Andean population group mentioned above.

Adugo

The Bororo people live in the Brazilian Amazon. Their game board is drawn on the ground and is identical to that of the trapial kuzen, except that in this version the jaguar is placed in the center of the square and the fourteen dogs are arranged around it (Drawing No. 1).

Objective: The same as in all previous games.

How to Play: The rules are the same as in the other games, except that in this one, the jaguar moves in the same way as in the komikan described by Matus (1920), being able to capture two dogs at a time if they each have an empty space adjacent to them. The jaguar wins the game if it captures 5 dogs; it loses if it is blocked by them.



Drawing Nº 1 https://es.wikipedia.org/wiki/Adugo

Conclusions

Based on the analysis conducted on board games from the southern tip of the continent, I believe that their origin and spread may have begun in a specific area of South America—one that remains unknown to us today—among the earliest human groups that migrated across the continent, and that their intergenerational transmission continued into historical times as a way of teaching hunting skills, in accordance with Gambier (1981), Magrassi and his team (1985), Huarita (2021), and subsequently, with the change in lifestyle due to sociocultural evolution, it may have simply become a game for entertainment. Another possibility, based on the studies by Romero (1943), is the original existence of a mythical connection between the game and hunting—a religious practice characteristic of pre-Hispanic peoples—which later became merely a game for entertainment rather than a teaching method or ritual performed prior to the hunt.

In some areas, it became a game that—in the case of the Andean world—continues to this day to be part of education in its two forms: tending sheep (Huarita 2021) or hunting the puma (Romero 1943).

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Fostering Sustainable Innovation: Applying Artificial Intelligence in Assessing the Distinctiveness of Scent Marks

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Abstract: Scent mark protection currently faces major hurdles due to the subjective nature of human olfactory perception and the lack of uniform standards for assessing distinctiveness across legal jurisdictions. This creates a critical legal gap that hinders businesses from registering and securing rights for non-traditional intellectual property assets. Addressing this issue, this study aims to construct a theoretical and practical framework evaluating the integration of artificial intelligence (AI) and complementary technologies to standardize the distinctiveness assessment of scent marks within a global legal context. Utilizing an interdisciplinary approach combining intellectual property law, sensory science, and digital technology alongside comparative legal analysis, the paper examines regulatory frameworks and landmark cases in the US, EU, and India, while evaluating the technical capabilities of Electronic Noses (E-nose), Gas Chromatography-Mass Spectrometry (GC-MS), AI algorithms, and Blockchain. The primary finding demonstrates that synthesizing physicochemical analysis tools with AI algorithms can objectively digitize sensory scent data into verifiable "olfactory fingerprints," effectively resolving visual representation barriers and providing a scientific basis to establish both inherent and acquired distinctiveness. Ultimately, these results offer a viable technological model to resolve practical bottlenecks in non-traditional trademark protection, while asserting the indispensable role of human oversight mechanisms (human-in-the-loop) to mitigate algorithmic black-box risks and maintain binding legal validity.
Keywords: Emerging Technologies; Scent Marks; Trademark Distinctiveness; Sustainable Innovation.

1. Introduction

The rapid development of new technologies such as artificial intelligence (AI) and blockchain is opening up many opportunities for innovation in the field of intellectual property, particularly for scent trademarks - a form of non-traditional trademark with the potential to become a new trend in brand identity and intellectual property protection. However, the protection of scent trademarks still faces many challenges, especially in determining distinctiveness, as there is no unified evaluation standard, even among countries with developed intellectual property systems. This lack of uniformity creates a need for an objective evaluation method capable of adapting to the sensory characteristics of scents and the differences between legal systems.

Previous studies have shown that olfactory stimuli influence human memory, behavior, and emotions more effectively than visual stimuli.[1] Therefore, in modern business marketing, companies no longer focus solely on visual marketing, through explosive advertising images, eye-catching product designs, etc. or auditory marketing, using music, melodies, etc. but have introduced new marketing strategies, such as olfactory marketing, for example, using a signature scent associated with a product. This context has created a requirement to expand the scope of protection for non-traditional trademarks, specifically, the protection of scent trademarks. Research on scent trademarks has become an engaging topic, attracting significant interest in the field of intellectual property. The rapid development of new technologies such

[1] Bruijn, M. J., & Bender, M. (2018). Olfactory cues are more effective than visual cues in experimentally triggering autobiographical memories. Memory, 26(4), 547–558. https://doi.org/10.1080/09658211.2017.1381744

as artificial intelligence (AI) and blockchain is opening up many opportunities for innovation in scent trademarks.

However, the protection of scent trademarks remains a relatively new topic in the field of intellectual property. At the same time, due to the nature of scents, establishing legal regulations for the protection of this type of trademark faces many challenges, especially in determining distinctiveness. Currently, there is no unified evaluation standard, even among countries with developed intellectual property systems. This lack of uniformity creates a need for an objective evaluation method capable of adapting to the sensory characteristics of scents and the differences between legal systems.

Although many studies have pointed out that the decisive factor in the protection of scent trademarks is determining the distinctiveness of the scent being protected, no research has yet delved into analyzing the challenges and the ability to determine the distinctiveness of scents to achieve a unified standard and the potential for applying new technologies to solve this difficult problem.

In this context, the research focuses on analyzing the potential for applying AI in identifying, analyzing, and evaluating the distinctiveness of scent trademarks, while also examining the support capabilities of new technologies in standardizing and enhancing the consistency of the evaluation process. Based on comparative legal research, an analysis of current standards for the distinctiveness of scent trademarks, and an interdisciplinary approach combining intellectual property law, new technology, and sensory science, the research constructs a framework for evaluating the applicability of AI to scent trademarks within the global legal context.

2. Scent Marks and the Assessment of Distinctiveness

The International Trademark Association (INTA) classifies trademarks into two main categories: traditional trademarks and non-traditional trademarks. Scent trademarks represent a form of non-traditional trademark characterized by their reliance on olfactory perception. This type of trademark is notably challenging to protect, as the difficulties in safeguarding scent trademarks stem from the limitations of human sensory perception and the absence of standardized systems for describing scents.[2] Although there are no explicit regulations regarding scent trademarks in international treaties, they may still be protected if they can demonstrate distinctiveness in accordance with the TRIPS Agreement. The TRIPS Agreement establishes distinctiveness as a prerequisite for trademark protection; similarly, under the Paris Convention, a trademark will be refused registration if it lacks “distinctiveness”. It can be asserted that without “distinctiveness” there can be no rights associated with a trademark.[3] Distinctiveness can be established through two forms: inherent distinctiveness and acquired distinctiveness. Inherent distinctiveness refers to signs that possess uniqueness, are not descriptive or functional, and can be recognized by consumers as indicating the commercial source solely through the sign itself. Acquired distinctiveness refers to signs that become associated with a commercial source and are demonstrated through usage.

Generally, inherent distinctiveness is only easily proven for visually perceptible trademarks. In contrast, acquired distinctiveness is often applied when protecting non-visually perceptible trademarks. For non-visible trademarks such as scent marks, because the nature of scent depends on olfactory perception, scent concentration, temperature, etc.; and sensitivity to smell varies among individuals as well as declines with

[2]Brill, G. E. (2022). Make some sense of scent trademarks: The United States needs a graphical representation requirement. *University of Richmond Law Review*, *56*(5), 19–43. https://scholarship.richmond.edu/lawreview/vol56/iss5/2

[3] Germain, K. B. (1985). [Review of the book *Trademarks and unfair competition* (2nd ed.), by J. T. McCarthy]. *Catholic University Law Review*, *34*(2), 595–601. https://scholarship.law.edu/lawreview/vol34/iss2/12

age (beginning to decline at age 20 for men and 40 for women),[4] proving inherent distinctiveness under current conditions appears to be impossible.[5] However, most countries currently have provisions concerning the inherent distinctiveness of trademarks, whereas relatively fewer countries have provisions governing the assessment of distinctiveness acquired through use; or, where such provisions exist, they are either unclear or difficult to apply in practice.

National and regional intellectual property laws currently protect scent marks to varying degrees. In the United States, one of the pioneers in scent mark protection worldwide, relatively specific rules have been developed regarding the demonstration of acquired distinctiveness for scents. In addition to requiring a description of the scent, U.S. law also requires applicants to provide substantial evidence of use, including a declaration indicating the filing basis (intent to use[6] or use in commerce[7]); a specimen containing the actual scent or flavor corresponding to the description of the claimed mark,[8] as well as evidence of the scent's recognition in the marketplace.

Before 2017, unlike the United States, EU law required a trademark to be represented graphically and to satisfy the seven Sieckmann criteria: clear, precise, self-contained (i.e., not requiring external elements to be understood), easily accessible, intelligible, durable, and objective.[9] This created a significant barrier to the protection of scent marks. The adoption of Directive (EU) 2015/2436 and Regulation (EU) 2017/1001 removed the mandatory requirement of "graphic representation,"[10] [11] thereby expanding the possibility of protecting non-traditional signs. However, the representation of the sign in the Register must still satisfy the seven Sieckmann criteria, and, to date, the EU has not recognized any additional cases of protection for scent marks. EU law is consistent with the TRIPS Agreement and U.S. law in recognizing both inherent distinctiveness and acquired distinctiveness.[12] However, in the EU, applicants are not required to declare

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[4] Richard Doty (2018), *"Age - Related Deficits in Taste and Smell",* Otolaryngologic Clinics of North America, 51(4), *815–825.* https://www.researchgate.net/publication/326404670_Age-Related_Deficits_in_Taste_and_Smell

[5] United States Patent and Trademark Office. (2026). Trademark manual of examining procedure (TMEP § 1202.13).https://tmep.uspto.gov/RDMS/TMEP/current

[6] Lanham Act, 15 U.S.C. § 1051(b) (1946).

[7] Lanham Act, 15 U.S.C. § 1051(a) (1946).

[8] United States Patent and Trademark Office. (2026). Trademark manual of examining procedure (TMEP § 904.03).https://tmep.uspto.gov/RDMS/TMEP/current

[9] Court of Justice of the European Union. (2002, December 12). Ralf Sieckmann v. Deutsches Patent- und Markenamt (Case C-273/00). ECLI:EU:C:2002:748. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A62000CJ0273&.com

[10] Regulation (EU) 2017/1001 of The European parliament and of the council (2017), Article 4: *"An EU trade mark may consist of any signs, in particular words, including personal names, or designs, letters, numerals, colours, the shape of goods or of the packaging of goods, or sounds, provided that such signs are capable of:*

(a)distinguishing the goods or services of one undertaking from those of other undertakings; and

(b)being represented on the Register of European Union trade marks ('the Register'), in a manner which enables the competent authorities and the public to determine the clear and precise subject matter of the protection afforded to its proprietor."

[11] Regulation on Community Trade Mark 40/94/EC (1993), Article 4: *"A Community trade mark may consist of any signs capable of being represented graphically, particularly words, including personal names, designs, letters, numerals, the shape of goods or of their packaging, provided that such signs are capable of distinguishing the goods or services of one undertaking from those of other undertakings."*

[12] Regulation (EU) 2017/1001 of the European Parliament and of the Council of 14 June 2017 on the European Union Trade Mark, arts. 7(1)(b), 7(3), 2017 O.J. (L 154) 1.

an "intent to use" status at the time of filing, thereby reducing administrative burdens and facilitating earlier registration. This mechanism potentially creates a risk of applications being filed solely for the purpose of securing rights, which is why the EU applies a post-registration review mechanism where there are indications of "bad faith."[13] Nevertheless, proving bad faith in practice remains complex, time-consuming, and costly.

3. The Application of AI in Assessing Scent Mark Distinctiveness

Unlike perceptible signs such as images, words, shapes, and the like, scents are intangible and elusive in nature, coupled with significant differences in olfactory perception among individuals. Scent marks therefore appear incapable of establishing inherent distinctiveness. In order to demonstrate the inherent distinctiveness of a scent sign, the greatest technical and legal barrier at present lies in its ability to be visually represented. While EU law, following the 2017 reforms, removed the requirement of graphic representation as a condition for the registration of scent marks, and U.S. law permits the registration of scent marks on the basis of acquired distinctiveness, certain countries and regions, such as Vietnam or India, continue to require all signs to be visually perceptible[14] [15] In the EU, the legal foundation of this impasse can be traced back to the landmark Sieckmann (C-273/00) case decided by the Court of Justice of the European Union (CJEU), which required non-traditional marks to be represented according to seven criteria, and these seven Sieckmann criteria continue to apply even after 2017. In Eden SARL v. OHIM (T-305/04), the Court rejected the use of the description "smell of ripe strawberries" in combination with an image of a strawberry to represent a scent sign, on the grounds that a description of a scent was insufficiently precise and could be affected by the variety of the plant[16], thereby resulting in a lack of objectivity and distinctiveness. The Court of First Instance of the European Communities (CFI) affirmed that verbal descriptions based on sensory perception are inherently subjective, chemical formulas represent compounds rather than the scent itself, and physical samples of scents deteriorate over time. Accordingly, the current examination guidelines of the European Union Intellectual Property Office (EUIPO) continue to classify scent marks as "not acceptable," as currently "generally available technology" is considered insufficient to represent such signs in accordance with the Sieckmann criteria.[17] However, given the current pace and level of technological development, the combination of electronic nose (E-nose) technology, gas chromatography - mass spectrometry (GC-MS), artificial intelligence (AI), and blockchain may constitute one of the feasible solutions for developing a scent representation that satisfies the criteria of identifiability and visual representation - an important requirement for demonstrating the distinctiveness of scent marks from a legal perspective. At the same time, such a combination could eliminate the subjectivity and instability that are inherent characteristics of scent signs in the examination of distinctiveness.

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[13] Regulation (EU) 2017/1001 of The European parliament and of the council (2017), Article 59.1b: *"An EU trade mark shall be declared invalid on application to the Office or on the basis of a counterclaim in infringement proceedings: where the applicant was acting in bad faith when he filed the application for the trade mark."*

[14] National Assembly of the Socialist Republic of Vietnam. (2022). Law No. 07/2022/QH15 amending and supplementing a number of articles of the Law on Intellectual Property. Art. 72(1)

[15] Pandit, U. P. (2026, February 13). India's first smell mark: Sumitomo rose-scented tires. WIPO Magazine. https://www.wipo.int/en/web/wipo-magazine/articles/indias-first-smell-mark-sumitomo-rose-scented-tires-89623?.com

[16] Eden SARL v. OHIM, T-305/04 (CJEU, 2005). https://curia.europa.eu/juris/liste.jsf?num=T-305/04

[17] Pandit, U. P. (2026, February 13). India's first smell mark: Sumitomo rose-scented tires. WIPO Magazine. World Intellectual Property Organization. https://www.wipo.int/en/web/wipo-magazine/articles/indias-first-smell-mark-sumitomo-rose-scented-tires-89623

From a technical perspective, an E-nose is a technology consisting of an array of gas sensors designed to simulate the functions of the human nose.[18] Through three principal components: (1) a sensor array, which receives the scent; (2) a pattern-recognition module, which analyzes scent signal patterns; and (3) a headspace sampling system, which collects gases from the scent sample to be analyzed[19], an E-nose uses the sensor array to record the responses of volatile organic compounds (VOCs), which are then digitized into an "olfactory fingerprint," enabling rapid scent classification through machine-learning algorithms. Meanwhile, GC-MS separates and accurately identifies individual chemical compounds through chromatograms and three-dimensional mass spectra,[20] generating a clear representation of each scent sign. The synergy between E-nose and GC-MS may generate a scientific data chain that is capable of both identifying the scent and providing objective and accurate information about the scent sign. This could satisfy the requirement of visual perception for the registration of non-traditional marks in certain jurisdictions around the world, while also supporting the demonstration of the inherent distinctiveness of a scent. However, from a legal perspective, GC-MS entails high costs and requires specialized expertise, making it difficult to access, while E-nose data are qualitative in nature and may be too complex for ordinary users to readily understand or remember. This may inadvertently fail to satisfy certain criteria under the trademark laws of jurisdictions such as the EU, which require a sign to be easily accessible.[21]

Recently, in India, an example illustrates how scientific and computational techniques may be combined to address this representational challenge. In November 2025, the Indian IP Office accepted its first olfactory trademark for Sumitomo Rubber Industries' rose-scented tyres.[22] The applicant utilized a seven-dimensional (7D) olfactory vector to provide a graphical representation of the scent sign. The vector diagram mapped the fragrance across seven fundamental coordinates: floral, fruity, woody, nutty, pungent, sweet, and minty, thereby converting the sensory characteristics of the fragrance into an objective graphical representation.[23] In addition, Sumitomo employed gas chromatography - mass spectrometry (GC-MS) to define the molecular fingerprint of its rose fragrance, providing a reproducible and objective basis for its identification. This case is particularly significant as it demonstrates an interdisciplinary approach in which legal experts, technologists, and domain scientists collaborated to satisfy the stringent requirements for the protection of a non-traditional trademark. This integrated approach may serve as a prototype model for other intellectual property authorities seeking to address the technical and legal challenges associated with olfactory marks.

In the current context, AI can be integrated as a tool for interpreting data to address the remaining limitations of E-nose and GC-MS. Rather than requiring trademark examiners to directly read and interpret

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[18] Tan, J., & Xu, J. (2020). Applications of electronic nose (e-nose) and electronic tongue (e-tongue) in food quality-related properties determination: A review. Artificial Intelligence in Agriculture, 4, 104–115. https://doi.org/10.1016/j.aiia.2020.06.003.

[19] Furizal, Ma'arif, A., Firdaus, A. A., & Rahmaniar, W. (2023). Future potential of e-nose technology: A review. International Journal of Robotics and Control Systems. https://pubs2.ascee.org/index.php/IJRCS/article/view/1091/html#id.3znysh7

[20] Diane Turner (2024). GC-MS Principle, Instrument and Analyses and GC-MS/MS, Technology Network. https://www.technologynetworks.com/analysis/articles/gc-ms-principle-instrument-and-analyses-and-gc-msms-362513

[21] Ralf Sieckmann v. Deutsches Patent- und Markenamt, Case C-273/00, ECLI:EU:C:2002:788 (Court of Justice of the European Union December 12, 2002).

[22] European IP Helpdesk. (2025, December 10). India's first olfactory trade mark. European Commission. https://intellectual-property-helpdesk.ec.europa.eu/news-events/news/indias-first-olfactory-trade-mark-2025-12-10_en

[23] Pandit, U. P. (2026, February 13). India's first smell mark: Sumitomo rose-scented tires. WIPO Magazine. World Intellectual Property Organization. https://www.wipo.int/en/web/wipo-magazine/articles/indias-first-smell-mark-sumitomo-rose-scented-tires-89623

large volumes of complex sensor signals or chromatographic - mass spectrometric data, machine-learning algorithms can process the data, extract relevant features, and cross-reference data from the two systems to construct a unified data profile for each scent sample. AI can identify similar patterns, classify scent signs, and detect differences between the sample sought to be registered and a reference sample, thereby supporting the development of an "odor fingerprint" capable of being stored, compared, and re-examined. Studies on E-nose technology have documented the use of machine learning for feature extraction, scent classification, and the mitigation of sensor drift, demonstrating that AI can play an important role in transforming sensor data into analytically meaningful information.[24] However, the application of AI does not imply the replacement of trademark examiners. AI-generated results should be regarded only as supporting technical data, providing examiners with an additional basis for assessing the consistency, distinctiveness, and degree of determinacy of a scent sign; the final determination as to whether the sign satisfies the requirements for protection must remain based on the applicable legal standards.

Blockchain is increasingly being considered for storing scent codes and related documents and reports, thereby ensuring the integrity and traceability of data throughout the analytical process. Specifically, raw datasets generated by E-nose and GC-MS can be processed by an AI model to conduct analysis and synthesis and to generate a detailed examination report. The entire process from the initial raw datasets to the AI-generated output report can be encoded into hash values and recorded together with fixed timestamps on a distributed ledger.[25] According to the definition provided by the National Institute of Standards and Technology (NIST), the tamper-evident and tamper-resistant properties of blockchain enable the detection of any interference with or alteration of stored data,[26] a mechanism that has been studied and tested by WIPO and EUIPO to authenticate the existence and originality of intellectual property at a specific point in time. Through the integrated system of E-nose, GC-MS, AI models, and blockchain, the examination of scent marks could be partially supported, thereby providing scent signs with an opportunity to demonstrate inherent distinctiveness.

Most applications are rejected because distinctiveness cannot be established; even if protection is granted, it requires an extremely costly and complex process of proving distinctiveness. In a notable case in the United States in 2018, to successfully secure trademark protection for the scent of Play-Doh modeling clay, Hasbro submitted over 300 pages of documentation, including marketing campaigns, product samples, and consumer surveys, to demonstrate that the scent - described as "sweet, slightly musky, with notes of vanilla and salty flour"[27] - had been associated with the Play-Doh brand by consumers for decades. This is currently the most viable method for establishing distinctiveness through use, but the biggest challenge lies in the burden of proof: TMEP §1202.13 requires the submission of a wide range of evidence, such as specimens, consumer survey results, marketing campaigns, commercial sales tied to the scent, and market uniqueness.[28] These requirements can easily pose a barrier for startups or businesses in the essential goods sector. On the other hand, to be deemed secondarily distinctive, the scent trademark must not be

[24] Ye, Z., Liu, Y., & Li, Q. (2021). Recent progress in smart electronic nose technologies enabled with machine learning methods. Sensors, 21(22), Article 7620. https://doi.org/10.3390/s21227620

[25] World Intellectual Property Organization. (2024). Part VII: Trade secrets and digital objects. In WIPO guide to trade secrets and innovation. https://doi.org/10.34667/tind.49735

[26] Yaga, D., Mell, P., Roby, N., & Scarfone, K. (2018). Blockchain technology overview (NIST Interagency Report 8202). National Institute of Standards and Technology. https://doi.org/10.6028/NIST.IR.8202

[27] Ward and Smith, P.A. (2018, March 23). Wake up and smell the . . . Play-Doh? Ward and Smith, P.A. Retrieved July 22, 2025, from https://www.wardandsmith.com/article/wake-up-and-smell-the-play-doh

[28] U.S. Patent and Trademark Office. (2022). *Trademark manual of examining procedure* (TMEP) (§ 1202.13 – Scent, fragrance, or flavor). https://tmep.uspto.gov/TMEP-1200.html#TMEP_1202.13

functional, which requires a rigorous screening, examination, and evaluation process. With the boom in new technologies, these issues are no longer as difficult to address; the application of technology can significantly reduce the burden on both the examining authority and the individuals or organizations seeking to protect scent trademarks.

First, AI is applied to analyze consumer ability to identify commercial origins and to filter data. Unlike manual qualitative assessment methods, which are time-consuming and prone to subjectivity, modern machine learning and big data analysis models can process vast amounts of information at superior speeds. AI models achieve an accuracy (measured by the AUC - Area Under the Curve index) of up to 85.6% in classifying responses, helping to filter out over 70% of noise data without losing core information.[29] Advanced machine learning algorithms (such as SVM and Deep Learning) achieve predictive accuracy in analyzing consumer sentiment and attitudes in the range of 80% to 89%, significantly outperforming manual dictionary-based analysis methods (which only reach about 60% - 70%).[30] Using AI instead of traditional, costly, and subjective questionnaires allows consumers to provide direct feedback via QR codes or NFC when interacting with products. Natural Language Processing (NLP) and sentiment analysis models then scrape, scan, and parse millions of online responses and reviews to measure results. Furthermore, integrating AI models allows the system to automatically parse and filter millions of feedback data points from the global market to immediately detect whether a scent is functional, thereby automatically applying exclusion criteria based on the functionality doctrine.

Second, after data collection, blockchain can be applied (Blockchain may simply be described as a decentralized method of recording any data, including but not limited to financial transactions, dispositions concerning value or assets, in a continuously encrypted and irreversible ledger[31]). Copyright protection research has shown that applying Blockchain to the construction of copyright protection systems can be very effective.[32] Once consumer feedback is collected, the data is synchronized to the blockchain to ensure authenticity. Since Blockchain technology is essentially a decentralized distributed ledger[33], which cannot be interfered with by third parties because records entered into the Blockchain storage are public, and records can only be added to the system as additions. This method facilitates direct verification of the acquired distinctiveness criteria while overcoming the risks of errors, manipulation, or delays commonly encountered in manual surveys.

4. Legal Directions for the Application of AI in Assessing Scent Mark Distinctiveness

In addition to the potential offered by E-nose technology, GC-MS, AI models, and blockchain systems in addressing the requirement of visual representation when demonstrating the inherent distinctiveness of scent signs, these technological models also entail considerable technical and legal risks. Complex AI

[29]Timoshenko, A., & Hauser, J. R. (2019). Identifying customer needs from user-generated content. Marketing Science, 38(1), 1–20. https://doi.org/10.1287/mksc.2018.1123

[30]Hartmann, J., Huppertz, J., Schamp, C., & Heitmann, M. (2019). Comparing automated text classification methods. International Journal of Research in Marketing, 36(1), 20–38. https://doi.org/10.1016/j.ijresmar.2018.09.009

[31]Gürkaynak, G., Yilmaz, İ., & Bengi, B. (2018). Intellectual property law and practice in the blockchain realm. Computer Law & Security Review, 34(4), 847–862. https://doi.org/10.1016/j.clsr.2018.05.027

[32]Liang, W., Zhang, D., Lei, X., Tang, M., Li, K. C., & Zomaya, A. Y. (2020). Circuit copyright blockchain: Blockchain-based homomorphic encryption for IP circuit protection. *IEEE Transactions on Emerging Topics in Computing*, *9*(3), 1410–1420. https://doi.org/10.1109/TETC.2020.2993032

[33]Esmaeilian, B., Deka, A., & Behdad, S. (2019). A blockchain platform for protecting intellectual property: Implications for additive manufacturing. In *International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (Vol. V004T05A011). American Society of Mechanical Engineers. .https://doi.org/10.1115/DETC2019-98293

models, such as deep learning, process sensor data from E-nose systems or GC-MS chromatographic – mass spectrometric data through millions of nonlinear parameters. This creates a significant barrier to transparency and accountability with respect to the processes and internal operations of an AI system.[34] In addition to the barriers associated with algorithms, the reports generated through AI-based synthesis and analysis depend entirely on the quality of the training data and input data. However, scent data collected by E-nose systems are subject to sensor drift caused by the physical aging of sensing elements or changes in environmental conditions. This requires advanced drift-correction techniques, as well as continuous calibration, to ensure that the AI model produces accurate classification results.[35] Moreover, AI is limited to measuring and analyzing the physical and chemical characteristics of a sign - namely, technical assessments - whereas, to satisfy the requirements for the registration of a scent mark in different countries or territories, a scent sign must possess not only technical distinctiveness but also distinctiveness under the applicable legal standards, such as the Sieckmann criteria in the EU and the criteria under Article 72 of Vietnam's Law on Intellectual Property. Therefore, AI and the complementary technologies proposed in this study can serve only as auxiliary tools, and the evidentiary materials generated through this process should be regarded only as supplementary evidence to assist trademark examiners during the examination process and applicants in substantiating their claims.

Through the Windsurfing Chiemsee case law, the Court of Justice of the European Union (CJEU) emphasized the holistic nature of the assessment process and acknowledged that, under appropriate conditions, opinion polls may be used to support the assessment of the competent authority (Joined Cases C-108/97 & C-109/97). AI and blockchain can be applied to reduce burdens; however, their capabilities do not automatically create a legal framework for the results produced by such technology. AI can assist in analyzing and processing complex data but carries the risk of "Garbage In, Garbage Out," as AI algorithms are not yet sufficient to accurately distinguish between genuine and fraudulent responses. On the other hand, blockchain may also face issues if applied in Europe due to violations of the principle of personal data erasure under the EU's General Data Protection Regulation.[36] Furthermore, the use of AI may encounter the "algorithmic black box" problem, violating the EU AI Act.[37] Even if a survey report shows a high rate of recognition, if it is based on an unlawful data collection process, it will be invalidated regarding its admissibility from the initial screening stage.[38]

Given these legal risks, in determining whether a trademark qualifies for acquired distinctiveness, the final decision rests with the examining authority, adhering to the "human-in-the-loop" principle. Tools that provide empirical correlation data must also be monitored, verified, evaluated, and trained by experts to ensure objectivity and fairness.

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[34] National Institute of Standards and Technology, "AI Risks and Trustworthiness," NIST AI Resource Center, 2023, https://airc.nist.gov/airmf-resources/airmf/3-sec-characteristics/.

[35] Tan, Y., Chen, Y., Zhao, Y., Liu, M., Wang, Z., Du, L., Wu, C., & Xu, X. (2025). Recent advances in signal processing algorithms for electronic noses. Talanta, 283, Article 127140. https://doi.org/10.1016/j.talanta.2024.127140

[36]European Union. (2016). Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation). Official Journal of the European Union, L 119, 1–88. (Article 17 - Right to erasure / 'right to be forgotten').

[37] European Parliament and Council. (2024). Regulation (EU) 2024/1689 laying down harmonised rules on artificial intelligence (Artificial Intelligence Act). Official Journal of the European Union, L 2024/1689.

[38]Voigt, P., & Von dem Bussche, A. (2017). The EU General Data Protection Regulation (GDPR): A Practical Guide. Springer.

5. Conclusion

In the context of rapid digital transformation, applying new technologies to the field of intellectual property is an inevitable trend. Scent marks, once limited by their subjective sensory nature, are now poised for widespread recognition and protection, similar to the evolution of sound marks, thanks to the ability to solve the core challenge of establishing distinctiveness.

Integrating technical solutions such as electronic noses, gas chromatography-mass spectrometry (GC-MS), artificial intelligence, and blockchain provides an objective method for analyzing, storing, and verifying scent characteristics. This serves as a crucial foundation for determining both inherent distinctiveness and acquired distinctiveness through use, facilitating registration, the establishment of standardized databases, and cross-border enforcement. Simultaneously, the growing awareness among businesses regarding brand value will drive significant investment into this type of intellectual asset.

Nevertheless, technology remains, by nature, a tool to support decision-making. To manage legal gray areas and algorithmic risks, the roles of system training, professional assessment, and final adjudication must remain with the competent examining authority. Maintaining direct human oversight is essential to ensuring the transparency, explainability, and binding legal validity of the scent mark protection system in the era of artificial intelligence.

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Benefit-sharing for traditional cultural expressions in the generative AI era: A comparative analysis of Indonesia, Malaysia and Vietnam under the WIPO IGC Draft Framework

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Abstract: Traditional cultural expressions (TCEs) generate substantial economic and cultural value for their communities, yet this value increasingly exposes them to unauthorized exploitation, a risk sharpened by generative AI (GenAI), which can reproduce and commercialize TCEs with minimal friction. While the World Intellectual Property Organization (WIPO)'s most recent draft (WIPO/GRTKF/IC/52/5) sets out benefit-sharing principles grounded in fair and equitable sharing, mutually agreed terms, and free, prior and informed consent, it remains non-binding and leaves implementation to individual states; existing scholarship has not systematically examined how Southeast Asian legal systems align with these provisions or how GenAI strains that alignment further. This paper addresses that gap through a comparative doctrinal analysis of Indonesia, Malaysia, and Vietnam against the WIPO Draft's benefit-sharing framework. It finds that Indonesia offers strong formal recognition but weak implementation due to state-centric management, Malaysia provides stronger community participation but suffers from federal-level inconsistency, and Vietnam lacks any dedicated legal framework for TCEs. Across all three, GenAI deepens these gaps by severing the traceable link between TCE use and resulting benefit, undermining both consent and accountability. The paper proposes traceability obligations for AI developers, a notification mechanism supporting meaningful FPIC, and a collective benefit-sharing fund for cases where individual attribution is not feasible, offering a practical path to operationalize existing WIPO and national commitments.

Keywords: Traditional Cultural Expressions; Benefit-sharing; Generative AI; WIPO IGC Draft Framework; Southeast Asia; Free, Prior and Informed Consent

I. Introduction

Traditional Cultural Expressions (TCEs) are more than remnants of the past; they generate income through creative industries and cultural tourism (Sinaga et al., 2025), command premium value for their authenticity (Hartati & Mala, 2025), and reinforce national identity and community pride (Zulhuda et al., 2025). Yet this same value exposes TCEs to unauthorized exploitation. TCEs are frequently commercialized without adequate consent or any guarantee of benefit-sharing, leaving communities exposed by their limited bargaining power within formal legal systems (Muda, 2026), while third parties continue to reproduce and appropriate these expressions with little consequence (Breemen, 2020). Generative AI (GenAI) has sharpened this vulnerability. What once required physical access to a community and considerable effort to draw "inspiration" from its heritage (Boucher, 2014) can now be reproduced, adapted, or commercialized with minimal friction (Dharmawan et al., 2024). TCEs also enter AI training datasets through user-uploaded content, digitization projects, or public registries, allowing models to learn from and exploit them without the consent or compensation of the originating community (Silva & Oliveira, 2024; Dharmawan et al., 2024)

At the international level, WIPO has sought to respond through the Intergovernmental Committee on Intellectual Property, Genetic Resources, Traditional Knowledge and Folklore (IGC), whose most recent draft, WIPO/GRTKF/IC/52/5, frames benefit-sharing around fair and equitable sharing, mutually agreed terms, and free, prior and informed consent. The text, however, remains a draft rather than a binding treaty, leaving implementation to individual states. This gap between international aspiration and domestic reality

is especially pronounced in Southeast Asia, a region whose cultural wealth is matched by few others but whose legal frameworks for protecting that wealth remain markedly uneven. From Indonesia's batik and Aceh's Saman dance to Malaysia's Kelantan batik and Zapin dance, the region's traditions are among the richest and most diverse in the world, yet national legal systems have not developed at a pace commensurate with this richness nor converged on a common approach to internalizing WIPO's emerging standards. This paper examines that unevenness through Indonesia, Malaysia, and Vietnam, comparing how each aligns with the benefit-sharing provisions of the WIPO IGC Draft and how GenAI further strains that alignment, closing with proposed safeguards, traceability, notification, and collective benefit-sharing to address the resulting gaps.

II. Findings and results

1. Definition and distinctive characteristics of TCEs

Traditional Cultural Expressions (TCEs) are defined by WIPO as forms of expression through which traditional culture is transmitted within a community, encompassing music, dance, art, designs, symbols, rituals, and handicrafts. TCEs constitute part of a community's identity and heritage, embodying knowledge, skills, and beliefs passed down through generations (WIPO, 2020) .

TCEs possess three key characteristics. First, they are collective in nature, formed by the cumulative contributions of multiple generations rather than a single individual (Khumairoh et al., 2022). Second, TCEs are dynamic and continuous; they are not merely handed down but remain actively practiced, adapted, and developed within the community (Ayu et al., 2022, cited in Susanti et al., 2026). Third, TCEs hold multidimensional value, encompassing social, spiritual, and identity-related significance alongside economic or aesthetic worth (Dzikri & Zulkifli, 2025). These characteristics indicate that TCEs cannot easily be attributed to a single author, an original version, or a specific moment of completion. Instead, they exist as an ongoing creative process deeply rooted in the community.

2. Intellectual Property rights protection for TCEs

TCEs may fall within the scope of various conventional intellectual property (IP) protection mechanisms, including patents, plant variety protection, trade secrets, trademarks, and copyright. However, these mechanisms do not protect TCEs to the same extent or for the same purposes. For instance, patents are rarely suitable for the direct protection of traditional cultural or artistic expressions, although documentation systems can indirectly strengthen a community's legal standing by recording TCEs and providing evidence in IP disputes (Maguipuinamei, 2016). Trade secrets can safeguard sacred or confidential traditional knowledge; however, the TRIPS framework requirement that protected information possess actual or potential commercial value may conflict with community interests in keeping sacred knowledge outside the realm of commercial exploitation (Bussey, 2014; Varadarajan, 2011). Similarly, trademarks can offer a means to protect traditional names, symbols, and signs used in commerce. Yet, the effectiveness of this mechanism is constrained by registration costs, the risk of third-party misappropriation, and the inability to prevent all forms of unauthorized or offensive use (Behrendt, 2000; Johnsson, 2012; Young, 2018; Nguyen, 2023; Prażmowska-Marcinowska, 2020; Rohde, 2024).

Among the aforementioned mechanisms, copyright has garnered the most attention in both academic and practical spheres, as its subject matter aligns more directly with the creative and expressive aspects of TCEs (Bussey, 2014). The practical significance of copyright is evidenced by findings that approximately 40–43% of surveyed Native American artists have utilized copyright law to protect their commercially distributed creative works (First Peoples Fund, 2013, as cited in Cheng et al., 2026). However, the potential for TCEs to be protected by copyright does not equate to comprehensive protection. Traditional copyright is structurally incompatible with TCEs, as it is built upon concepts such as individual authorship, originality, transferable ownership, finite terms of protection, and personal moral rights (Molina, 2024). These premises conflict with the collective, intergenerational, and culturally embedded nature of TCEs, which may be sacred, non-commercial, and continuously transmitted by the community across generations (Boateng, 2011; Erlina & Safriti, 2022; Dladla, 2024; Breemen, 2020). Furthermore, the finite protection periods and the individualistic conception of moral rights in copyright law struggle to align with

community demands for continuous protection and the preservation of collective cultural integrity (Berne Convention, 1971, Art. 7(1); Posey & Dutfield, 1996; Molina, 2024). This tension highlights a broader limitation noted by Cheng et al. (2026), who point out that traditional intellectual property mechanisms can protect specific expressions of indigenous cultural heritage, yet their underlying legal structures do not fully accommodate the collective nature and cultural embeddedness of TCEs.

3. Sui generis protection of TCEs and the role of benefit-sharing

The structural limitations of conventional IP protection support the need for a sui generis regime tailored to the collective, intergenerational, and culturally embedded nature of TCEs. Such a regime should not simply extend exclusive rights over TCEs, as overly broad protection may restrict the public domain and constrain collective cultural creativity (Boyle, 2003; Brown, 1998), while imposing external copyright rules may undermine Indigenous self-determination (Reed, 2020). Instead, sui generis protection should establish rules that recognize community interests, protect cultural integrity, and regulate the legitimate use of TCEs. Within such a framework, benefit-sharing provides a means of ensuring that communities receive a fair share of the benefits arising from the use of their cultural expressions without requiring TCEs to be treated solely as conventional forms of private property.

Benefit-sharing serves as a crucial mechanism to ensure that communities derive benefits from the use and exploitation of TCEs. This mechanism is understood as the distribution of benefits arising from the exploitation of traditional knowledge or TCEs to the relevant communities (Simatupang, 2024). The foundation of benefit-sharing lies in principles of equity, collective rights, and the recognition of community contributions to the preservation and development of cultural heritage (Siswoyo, 2024). Shared benefits may encompass financial compensation, capacity building, participation in decision-making processes, and legal or ethical recognition (Susanti, 2026), which not only distributes economic value but also bridges the gap between commercial exploitation and cultural preservation (Siswoyo, 2024). However, the current legal framework remains fragmented and has yet to establish a comprehensive, unified, and binding obligation covering all forms of TCE exploitation. This gap is particularly significant when TCEs are incorporated into new technologies, where exploitation can occur on a large scale and generate economic value that traditional mechanisms were not designed to distribute.

- 4. The WIPO IGC Draft framework on benefit sharing

4.1 Principle

At the international level, the World Intellectual Property Organization (WIPO), through the Intergovernmental Committee on Intellectual Property, Genetic Resources, Traditional Knowledge and Folklore (IGC), has developed draft provisions for the protection of Traditional Cultural Expressions (TCEs). The latest text, WIPO/GRTKF/IC/52/5 (WIPO, 2025), sets out alternative approaches to beneficiaries' rights, conditions of use, and administration. Within this broader framework, benefit-sharing is grounded in the Preamble. Paragraph 9 links the use of TCEs to mutually agreed terms, fair and equitable benefit-sharing, and the free, prior and informed consent, approval and involvement of Indigenous Peoples, local communities, and other beneficiaries. Moreover, paragraphs 8 and 11 further emphasize the common social and economic benefits of TCE use for holders and users.

4.2 Scope

The specific legal basis for benefit-sharing is set out in Article 5 of the Draft concerning the scope of protection. Under the Original Facilitators' Alternative, Article 5(a)(ii) recognizes the collective right of beneficiaries to "receive a fair and equitable share of benefits arising from the utilization" of TCEs that are subject to restricted access. The Draft simultaneously draws a clear distinction between restricted and unrestricted TCEs. While restricted TCEs are tied to strict control over use, Article 5(b)(i) provides that beneficiaries of unrestricted TCEs may still retain the right to receive a fair and equitable share of benefits. Consequently, the Draft separates the obligation of benefit-sharing from exclusive control over access,

ensuring that communities remain fairly compensated even when their heritage has already entered wider circulation.

Alternative 2 further clarifies the scope of benefit-sharing by differentiating the mechanisms available according to the accessibility of TCEs. For restricted-access TCEs, beneficiaries may exercise stronger control over use, creating a basis for negotiating the conditions of use and the sharing of resulting benefits. For TCEs that are more widely accessible, direct control is reduced, but the possibility of benefit-sharing is not necessarily eliminated. In particular, Alternative 2, Article 5(c)(iv) provides that, where applicable, users of widely known TCEs or TCEs in the public domain may be required to deposit a user fee into a fund constituted by the Member State. The Draft therefore contemplates both direct benefit-sharing through arrangements with beneficiaries and a fund-based mechanism for more publicly accessible TCEs.

4.3 Operational mechanisms

The Draft further provides procedural mechanisms through which beneficiaries may exercise their rights and participate in decisions concerning the use of TCEs. For restricted-access TCEs, Alternative 2 of Article 5 links access and use to free, prior and informed consent (FPIC), approval and involvement, as well as mutually agreed terms (MAT). FPIC ensures that the use of TCEs is preceded by meaningful community participation and consent, while MAT provides a basis for negotiating the conditions of use between beneficiaries and users. Such agreements may therefore provide a basis for determining benefit-sharing arrangements, although the Draft does not expressly require every agreement to include benefit-sharing.

4.4 Implementation

Article 6 provides an institutional mechanism for implementing the rights and interests of beneficiaries. Under Alternative 1, Article 6.1, Member States or Contracting Parties may establish or designate a competent authority to administer these rights in close consultation with beneficiaries. Alternative 2 adopts a stronger participatory approach by requiring such authority to operate with the explicit consent of or in conjunction with beneficiaries. This provides an institutional mechanism through which the rights and interests of beneficiaries can be administered and implemented in practice.

Despite its comprehensive structure, the WIPO framework leaves several core issues regarding benefit-sharing unresolved: it lacks a unified formula for calculating equitable shares, does not mandate benefit-sharing negotiations for every usage agreement, and relies on national implementation capacity rather than establishing an internationally standardized fund mechanism. Furthermore, WIPO/GRTKF/IC/52/5 remains a draft subject to revision rather than a legally binding international treaty. Consequently, while it establishes a vital foundation for recognizing community rights, the framework leaves the determination of specific details and practical implementation to future negotiations and national legislation.

- 5. National legal compatibility

Indonesia, Malaysia, and Vietnam were selected because they combine substantial TCE resources with markedly different legal responses to their protection, allowing the comparison to capture a genuine spectrum: Indonesia's extensive formal recognition weakened by state-centric implementation, Malaysia's stronger community participation model constrained by federal inconsistency, and Vietnam's complete absence of a dedicated TCE framework. The three countries also occupy a broadly comparable position in AI governance development, being grouped among the "Promising" states actively building national AI strategies and piloting ethics frameworks (Chua et al., 2025), which allows the analysis to assess how GenAI strains each TCE regime without the confound of vastly different starting points in AI regulation itself.

6. 5.1 Indonesia

Indonesia has established a relatively extensive legal basis for the protection of communal cultural heritage. Article 18B(2) of the 1945 Constitution recognizes indigenous communities and their traditional rights, while the Copyright Law 2014, Cultural Advancement Law 2017, and Government Regulation No. 56/2022 on Communal Intellectual Property provide additional mechanisms for the protection and management of communal cultural expressions (Irawan et al., 2025). The framework therefore demonstrates a clear recognition of the collective dimension of cultural heritage. At the institutional level, the state remains the principal actor in exercising and administering these rights (Disemadi et al., 2023), which is broadly consistent with Alternative 1 of Article 6 of the WIPO IGC Draft.

The stronger concern lies in the limited role of beneficiaries within this state-centered system. In practice, state and local authorities may authorize, promote, or commercialize cultural expressions without sufficient consultation with the communities concerned (Gunawan, 2025). Thus, the community remains primarily recipients of state protection rather than participants in decision-making, leading to weaker protection for community autonomy and control (Susanti et al., 2026). Without meaningful participation before exploitation occurs, communities have limited opportunities to determine whether a proposed use is acceptable, what conditions should apply, and what benefits should be provided in return.

This problem is further reflected in the limited development of Mutually Agreed Terms (MAT) and licensing arrangements. Indonesian law provides limited detailed guidance on how consent to the commercial use of TCEs should be translated into legally enforceable agreements defining the rights and obligations of users and communities (Asmorowati & Nashihah, 2022). In particular, the existing framework does not sufficiently clarify matters such as licensing conditions, remuneration, revenue allocation, and the distribution of economic benefits arising from the commercial exploitation of TCEs (Zaliaokta et al., 2026). This absence directly affects the feasibility of the benefit sharing mechanism when the parties lack the ability to determine what benefits are to be provided, who is entitled to receive them, how they are calculated, and how the relevant obligations can be obliged. Where cultural heritage is commercialized by public authorities or third parties, such activities may occur without clear agreements establishing legally binding obligations to share the resulting benefits with the concerned (Susanti et al., 2026). Consequently, there may be no predetermined legal mechanism through which a portion of that value is returned to the communities that maintain the relevant TCEs when commercialization generates economic value.

The weakness in benefit-sharing is further compounded by regulatory fragmentation and enforcement constraints. Existing provisions remain fragmented and do not yet establish a sufficiently coherent framework for identifying, allocating, and distributing benefits arising from the use of TCEs (Agustianto et al., 2024; Susanti et al., 2026). Regulatory fragmentation between national and local levels also complicates the establishment of consistent rules on authorization and benefit-sharing (Hanifuddin, 2021). In addition, incomplete documentation of TCEs, particularly in remote areas, limited inter-agency coordination, and the absence of a comprehensive national database may make it difficult to identify protected expressions, their originating communities, and the beneficiaries entitled to receive benefits (Salama, 2024; Rizka et al., 2024; Rubi et al., 2024). These practical limitations weaken the ability of communities to assert their rights even where formal legal recognition exists.

Indonesia, therefore, shows a relatively strong degree of formal recognition but a weaker degree of alignment in implementation. These gaps are particularly relevant when assessing whether the existing framework can respond adequately to new forms of large-scale and commercially oriented exploitation, including those associated with generative AI.

7. 5.2 Malaysia

Malaysia's legal framework regarding TCEs is currently primarily derived from the National Heritage Act 2005 (Act 645), while a draft law on Traditional Knowledge and Traditional Cultural Expressions has

been proposed to establish a more specialized protection mechanism (Sulaiman, 2022). Compared to Indonesia, this approach reflects a shift from mere heritage preservation toward granting control and facilitating the controlled exploitation of the economic value of TCEs. Some studies suggest that Malaysia's specialized legislative approach closely aligns with the direction of "Alternative 2" under Article 6 of the WIPO framework, particularly in its emphasis on the participation of beneficiaries (Sulaiman, 2022).

Regarding control and community participation, studies on the draft law indicate that communities are granted a more significant role in determining how TCEs are used, reproduced, commercialized, and distributed (Ayu et al., 2022). Consequently, the use of TCEs by third parties is not viewed solely through the lens of regulatory licensing but is also contingent upon the consent of the relevant community (Yuniar & Najicha, 2024). This enables communities to participate in defining terms of use, thereby establishing a basis for negotiating and distributing benefits arising from the exploitation of TCEs.

The aspect of benefit-sharing is also interpreted more broadly than mere financial compensation. Studies suggest that benefits derived from the use of TCEs can be distributed through financial compensation, capacity building, support for cultural preservation, or the enhancement of the community's socio-economic capabilities (Triatmanto et al., 2024). At the same time, Malaysia possesses a documentation system and specialized agencies that support the identification and management of cultural heritage, thereby facilitating the recognition of TCEs and relevant stakeholders (Ng, 2024; Safitri, 2024).

However, legal alignment does not necessarily equate to effective implementation. Malaysia’s federal structure results in state-level variations regarding cultural policies and practices, which can lead to inconsistencies in the application of FPIC and community participation (Abdullah et al., 2020). Furthermore, community participation takes place within a system where the state retains a significant management role, raising questions about the extent of autonomy and the substantive nature of such participation (Sahara & Aini, 2025). Consequently, the gap in Malaysia’s approach lies primarily in the ability to translate these principles into rights that can be consistently exercised in practice.

Overall, Malaysia demonstrates a higher degree of alignment with criteria regarding community participation, control over usage, and benefit-sharing compared to Indonesia’s state-centric management model. Nevertheless, the division of authority among states and the state's strong regulatory role continue to limit the extent of genuine community autonomy.

8. 5.3 Vietnam

Unlike Indonesia and Malaysia, Vietnam has not yet established a specific legal framework for TCEs. Some TCEs may fall within the scope of the 2024 Law on Cultural Heritage, particularly when they are simultaneously classified as intangible cultural heritage; however, the scope of "intangible cultural heritage" under Vietnamese law is broader, and not all subjects within this category necessarily qualify as TCEs under the WIPO approach. The Law on Cultural Heritage primarily governs the management, protection, and promotion of heritage values, whereas the Law on Intellectual Property protects intellectual property subject matter that meets the relevant legal criteria. Consequently, these two systems have not yet formed a unified legal regime regarding community rights over TCEs.

Regarding community rights, the 2024 Law on Cultural Heritage recognizes collective ownership of intangible cultural heritage, including the know-how and skills associated with its practice, that is created, inherited, held, practiced, and transmitted by communities or groups of people (Article 4); it also acknowledges the right of heritage holders to determine which elements require protection, as well as the forms and extent of the heritage's promotion (Article 6). These provisions establish a foundation for recognizing the role and collective rights of communities, aligning with certain WIPO guidelines concerning beneficiaries. However, these rights remain framed within the context of cultural heritage

management and protection; they have not yet been translated into a distinct collective right over TCEs that would enable control over third-party usage.

A more significant gap exists regarding benefit-sharing. Article 5 of the Law on Cultural Heritage recognizes the right of heritage owners to benefit from the protection and promotion of heritage values, while also establishing support policies for artisans, practitioner groups, and conservation activities. However, these mechanisms primarily distribute public support and benefits derived from conservation efforts rather than establishing a community right to benefits arising from third-party use of TCEs. Consequently, they do not equate to the mechanism outlined in Article 5 of the WIPO Draft, which grants beneficiaries the right to receive a fair and equitable share of benefits arising from the utilization of TCEs. In other words, while Vietnamese law currently recognizes the right to benefit from heritage protection and promotion, it has not yet clearly established a right to benefit from the commercial exploitation of TCEs by users. Similarly, current regulations concerning community consent primarily facilitate activities such as heritage management, inscription, research, and documentation, rather than establishing a community right to approve or refuse third-party use of TCEs. Thus, while these regulations reflect community involvement in heritage governance, they do not yet constitute a control mechanism over the use of TCEs that aligns with the "consent/approval" and "mutually agreed terms" models found in the WIPO Draft. This is particularly significant given that current intellectual property law continues to structure rights around statutorily defined intellectual property subject matter, rather than establishing a Sui generis right for communities regarding TCEs.

When viewed against WIPO criteria, Vietnamese law has not yet established a specialized protection mechanism for TCEs, specifically regarding the right to control their use and the right to share in the benefits derived from their exploitation. Existing support mechanisms for artisans, communities, and heritage preservation are primarily state-funded rather than based on benefit-sharing arrangements between communities and users. This gap is increasingly critical given the potential for TCEs to be digitized and exploited on a massive scale in the era of GenAI.

6. Generative AI and the practical limits of TCE benefit-sharing

6.1 Challenges in identifying TCE use and benefits

The WIPO draft links benefit-sharing to the use of TCEs. Under Article 5, beneficiaries may receive a fair and equitable share of the benefits arising from the use of TCEs. In certain instances, such use is also contingent upon the consent, approval, or participation of the beneficiaries or on terms mutually agreed upon by the parties (WIPO, 2025). This structure implies that, in practice, WIPO's benefit-sharing mechanism requires identifying which TCE was used, who used it, and what benefits arose from that use. In traditional forms of exploitation, this connection is often relatively easy to discern. For instance, if a business uses a traditional pattern to manufacture clothing, one can identify the cultural expression employed, the entity exploiting it, and the commercial product generating the benefits. GenAI complicates this relationship. A TCE might be included in a training dataset alongside millions of other documents and subsequently become part of the process that shapes the model's capabilities without necessarily being reproduced intact in any specific output. The final product could be a new image, song, or design in which traces of the original TCE are no longer readily identifiable. Dugeri (2024) points out that works from Indigenous communities can serve as input data for GenAI systems while also being reflected in the systems' generated outputs. Consequently, economic value no longer resides directly within the TCE itself but may be generated at various subsequent stages. This creates a particular challenge for benefit-sharing; even if a community is entitled to benefits from the use of a TCE, they may struggle to pinpoint exactly which act of usage generated the benefits and which entity is responsible for sharing them. This issue does not imply that every instance of incorporating TCEs into training data is automatically unlawful. Montesdeoca Molina does not draw such a conclusion; rather, she notes that the legality of using data to train AI depends on the laws and exceptions specific to each intellectual property system (Molina, 2024).

The crucial point regarding benefit-sharing lies elsewhere. Generative AI makes it more difficult to identify specific instances of use and the link between such use and economic benefits. Consequently, the challenge is no longer merely how benefits should be shared but how to determine whether the use of TCEs gives rise to a right to benefit in the first place.

6.2. Challenges in obtaining consent for the use of TCEs

This legal challenge is intensifying as TCEs are digitized and become widely available online. The public display of cultural heritage in a digital environment does not imply that the originating community has consented to every form of subsequent technological exploitation. Although initial digitization efforts often serve non-commercial objectives, such as archiving, research, or public dissemination, these very digital datasets can inadvertently become input resources for AI development. Specifically, Oruc (2025) asserts that digitized cultural heritage is highly susceptible to being repurposed as training data for AI models, regardless of the fact that the original digitization project was never intended for commercialization. Consequently, clearly distinguishing between technical accessibility and cultural-legal authorization is paramount. The public availability of a TCE online cannot be automatically equated with community consent for technology companies to freely incorporate it into training datasets and commercialize the resulting products. If public access is conflated with the freedom to exploit, the heritage-holding community is immediately stripped of its role as a decision-maker from the very outset. As a result, rather than actively participating in setting terms of use and negotiating value distribution prior to commercialization, the community is relegated to a passive position, able only to seek partial compensation after the exploitation has already occurred.

The emergence of GenAI has starkly exposed the inherent gap between the ability to observe and collect a TCE and the community's genuine consent regarding the exploitation of that heritage. This gap poses a direct challenge to the benefit-sharing model promoted by WIPO. This is because a substantive and sustainable benefit-sharing mechanism requires granting the relevant communities legal standing early in the value chain, ensuring they possess full information, the right to participate, and equal bargaining power before any exploitation of TCEs takes place.

6.3. Challenges for national benefit-sharing frameworks

The difficulties mentioned do not stem from weaknesses in national law enforcement, but rather from the collapse of the very premise upon which the WIPO Draft is built. Specifically, the Draft's mechanisms, such as benefit-sharing (Article 5), institutional governance (Article 6), and the requirements for Free, Prior and Informed Consent (FPIC) and Mutually Agreed Terms (MAT), rely on the assumption that the use of TCEs involves identifiable subjects, clear attribution, and the possibility of negotiation. GenAI, however, has completely erased that premise, as once TCEs are absorbed into large-scale training datasets, there is no longer a discrete act of use, user, or beneficiary to which Article 5 can be applied. Consequently, even if countries like Indonesia, Malaysia, or Vietnam were to fully align their legal frameworks with the WIPO Draft, the challenges posed by GenAI would remain undiminished.

In Indonesia, Malaysia, and Vietnam specifically, this challenge is exacerbated by the interplay between existing legal gaps regarding TCEs and the regional AI governance landscape. Notably, Southeast Asian nations generally favor voluntary, non-interventionist approaches, whereas legally binding risk governance frameworks exist only in Singapore and Thailand (Chua et al., 2025). Furthermore, global training datasets lack regional cultural content (Isono & Prilliadi, 2023; Larasaty et al., 2026), relegating the region to the status of a "price taker" with limited leverage to influence foreign AI developers (Chua et al., 2025; Draux, 2024). Due to the absence of domestic governance tools mandating TCE disclosure or traceability, the existing legal gaps in Indonesia, Malaysia, and Vietnam will interact more directly and acutely with the traceability challenges posed by generative AI, without any mitigating regulatory mechanisms in place.

These challenges are further amplified across the three legal systems. In Indonesia, difficulties in identifying beneficiaries and ensuring community participation already make it difficult to determine who holds rights over TCEs and who is entitled to benefits. GenAI makes this harder because TCEs may pass through datasets, AI developers, and technology platforms across different jurisdictions, making the

responsible party difficult to identify. Malaysia provides stronger protection for community participation and control, but this does not necessarily ensure benefit-sharing. If communities cannot identify who used their TCEs, developed the AI model, or gained commercial value from it, their right to participate may not translate into a practical claim to benefits. Vietnam faces a more fundamental gap because its current legal framework does not clearly give communities the right to control third-party use of TCEs or claim benefits from their commercial exploitation. GenAI therefore exposes both enforcement gaps and gaps in the underlying rights. Across all three systems, it increases the distance between TCEs and the economic value generated from them. As TCEs move through datasets, AI models, and commercial products, communities face greater difficulty identifying who used their cultural expressions and what value they generated. Effective benefit-sharing therefore requires more than recognizing a right to benefits. Communities must also be able to identify the use of their TCEs, the actors involved, and the benefits generated from that use. Without these mechanisms, the right to fair and equitable benefit-sharing may remain difficult to enforce in practice.

III. Conclusion and recommendation

This article examines how the WIPO IGC Draft's benefit-sharing provisions interact with the protection of TCEs in three Southeast Asian countries, and how generative AI complicates that interaction. TCEs are collective, continuously evolving, and multidimensional, and conventional intellectual property mechanisms, built around individual authorship and finite terms, only partially accommodate them. This mismatch supports a sui generis approach in which benefit-sharing ensures communities receive a fair return from their heritage. The WIPO Draft grounds this in fair and equitable sharing, mutually agreed terms, and free, prior and informed consent, but remains non-binding and leaves implementation to national law. Indonesia, Malaysia, and Vietnam each fall short differently in nationalizing. Indonesia's extensive formal recognition is undermined by state-centric administration that leaves communities as recipients rather than negotiating parties. Malaysia's stronger participation rights are undermined by federal inconsistency in their application. Vietnam has no dedicated TCE regime at all, recognizing a right to benefit from state-led protection but not from third-party exploitation. Generative AI does not merely widen these gaps; it exposes a flaw in the WIPO Draft's own assumptions, since benefit-sharing presupposes a traceable link between use and benefit that AI training routinely severs, even under full national compliance. Southeast Asia's soft-law preference in AI governance, its underrepresented languages and cultural data, and its limited leverage over foreign developers compound this further, leaving Indonesia unable to trace uses it once could identify, Malaysia unable to find a counterparty for rights that presume one exists, and Vietnam with no entitlement for GenAI to erode in the first place.

To enable a benefit-sharing mechanism within the GenAI environment, the law need not create a new right for communities; instead, it should introduce mechanisms that facilitate the practical implementation of existing rights, specifically FPIC and the right to benefit-sharing. Primarily, AI developers utilizing TCEs in training data should be required to maintain basic records regarding the TCE's origin, the associated community (where identifiable), the basis of access, and any known cultural restrictions. This obligation does not require the public disclosure of the entire training dataset but aims to create a record sufficient to trace the inclusion of the TCE within the AI system. Consequently, when an identifiable TCE is used for commercial purposes, the enterprise should be obligated to notify the relevant community or competent authority either prior to or during the system's development. This notification mechanism does not replace FPIC but rather facilitates its substantive implementation, as communities cannot consent, refuse, set conditions for use, or negotiate benefits if they are unaware that their TCEs are being utilized. However, it is not always possible to trace a TCE back to a specific community or output. A single dataset may contain TCEs from multiple communities, while an AI model may not maintain a clear link between a specific TCE and the final product. In such instances, national legislation should consider establishing a collective benefit-sharing mechanism whereby commercial entities using protected TCEs contribute to a fund jointly managed by the state and community representatives. These funds could be allocated to cultural preservation, the maintenance of traditional practices, or other community-determined purposes. This approach does not supersede the individual community's rights to FPIC or benefit-sharing; rather, it

addresses the gap that arises when GenAI makes it difficult to individually identify users, specific TCEs, and the resulting benefits. Instead of merely requiring adherence to FPIC, the proposed mechanism establishes a chain of safeguards, comprising traceability, notification, and collective benefit-sharing, to address cases where individual traceability is not possible.

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AI Ethics and Indigenous Data Sovereignty: Framework for Inclusive and Sustainable Development

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Abstract: Artificial intelligence (AI) is increasingly influencing healthcare, education, environmental management, economic planning, public administration, and scientific research. Although these technologies offer substantial opportunities for sustainable development, their application to Indigenous communities raises important ethical concerns related to data ownership, cultural integrity, consent, representation, privacy, and unequal distribution of technological benefits. Conventional approaches to data governance often treat data primarily as a technical or economic resource and may inadequately recognize Indigenous peoples' collective rights, cultural knowledge, governance systems, and relationships with land and community. Indigenous data sovereignty provides an alternative framework that emphasizes the authority of Indigenous peoples to govern the collection, ownership, access, interpretation, use, and dissemination of data concerning their communities, territories, and knowledge systems. This review examines the intersection of AI ethics and Indigenous data sovereignty and evaluates existing principles, governance approaches, and emerging frameworks for responsible AI development. Relevant scholarly literature, international policy documents, Indigenous-led frameworks, and reports addressing AI governance, data sovereignty, Indigenous knowledge, and sustainable development were reviewed thematically. The review identifies major challenges involving extractive data practices, algorithmic bias, inadequate consent mechanisms, commercialization of Indigenous knowledge, limited Indigenous participation in AI development, and technological inequities. It further highlights the importance of Indigenous-led governance, collective consent, transparency, accountability, data stewardship, benefit sharing, and culturally appropriate technological design. Building on these principles, the review proposes an inclusive framework connecting AI ethics with Indigenous data sovereignty to support equitable participation, protection of cultural knowledge, community self-determination, and sustainable development. Integrating Indigenous governance principles into AI systems can contribute to more just, culturally responsive, and socially sustainable technological innovation.
Keywords: Artificial intelligence; AI ethics; Indigenous data sovereignty; Indigenous knowledge; sustainable development

1. Introduction

Artificial intelligence (AI) has become an important component of contemporary technological transformation, with applications extending from automated decision-making and predictive analytics to healthcare, education, agriculture, environmental monitoring, and public governance. The increasing availability of large datasets and advances in machine learning have created opportunities to address complex social, economic, and environmental challenges. AI is consequently being positioned as an important instrument for social and economic transformation, although its effects on society and culture extend beyond technological efficiency (Li, 2020).

The rapid development of AI has simultaneously generated significant ethical, governance, and policy challenges. Questions concerning accountability, transparency, privacy, discrimination, human rights, and regulatory oversight have become central to discussions about responsible AI (Keles, 2023; Manheim & Kaplan, 2019; Renda, 2019; Rotenberg, 2024). The emergence of increasingly data-intensive AI systems

also creates concerns regarding who controls data, who determines their permitted uses, and who benefits from technologies developed from them.

These concerns become particularly significant in Indigenous contexts. Indigenous peoples possess diverse knowledge systems developed through long-term relationships with communities, lands, waters, ecosystems, and cultural practices. Indigenous knowledge should therefore not be regarded simply as an information resource that can be extracted and incorporated into technological systems. Indigenous knowledge systems represent distinctive ways of understanding and interacting with the world (Barnhardt & Kawagley, 2005; Mazzocchi, 2020).

The sustainability implications of Indigenous knowledge are increasingly recognized in scholarship. Indigenous approaches can provide alternative understandings of sustainability based on relationships, responsibilities, reciprocity, stewardship, and long-term ecological considerations (Jamieson, 2010; Mazzocchi, 2020). Māori concepts such as *kaitiakitanga*, for example, emphasize active guardianship and responsibilities toward the natural world and future generations (Kawharu, 2000; Paul-Burke & Rameka, 2015). Such perspectives have important implications for how AI systems should be designed and governed when they interact with Indigenous communities and environments.

The concept of Indigenous data sovereignty has emerged partly in response to these challenges. It emphasizes Indigenous peoples' rights and interests in governing data relating to their peoples, communities, territories, resources, and knowledge. Kukutai and Taylor (2016) positioned Indigenous data sovereignty within the broader context of Indigenous self-determination, while subsequent scholarship has emphasized the importance of Indigenous governance and control over data practices (Kukutai et al., 2020).

Data sovereignty is particularly relevant to AI because AI systems depend on extensive datasets for training, validation, deployment, and evaluation. When Indigenous data are incorporated into such systems without appropriate governance, communities may have limited influence over how their information is interpreted or subsequently used. The problem is therefore not simply one of privacy but also one of authority, representation, cultural integrity, and self-determination.

The decolonization of AI governance has consequently become an important area of research. Ayana et al. (2024) highlight the need to examine AI governance through contexts outside dominant technological and institutional models, while Hooper and Oyege (2024) emphasize the potential contribution of African Indigenous knowledge systems to AI ethics research and education. Similarly, Abdilla et al. (2021) argue for Indigenous protocols capable of guiding the development and use of AI according to Indigenous perspectives.

The intersection of AI ethics and Indigenous data sovereignty therefore requires a broader understanding of responsible technological development. Conventional AI ethics emphasizes principles such as fairness, transparency, accountability, privacy, and safety (Patel, 2024; Renda, 2019). Indigenous approaches can extend these principles by emphasizing collective rights, relational responsibilities, cultural protocols, stewardship, reciprocity, and community authority.

This review examines the relationship between AI ethics and Indigenous data sovereignty and explores how these concepts can be integrated into a framework for inclusive and sustainable development. It considers ethical risks associated with Indigenous data and AI, Indigenous knowledge and technological systems, governance principles, barriers to participation, and opportunities for community-centered AI development.

2. Conceptual Foundations

2.1 Artificial intelligence and ethical governance

AI ethics encompasses principles and practices intended to ensure that AI systems are developed and deployed in ways that respect human rights, minimize harm, promote fairness, and maintain

accountability. The expansion of AI has made questions of governance increasingly important because algorithmic systems can influence decisions affecting individuals and communities (Renda, 2019; Rotenberg, 2024).

Privacy represents another major concern. AI systems can process extensive quantities of personal and behavioral information, potentially creating risks for individual privacy and democratic institutions (Manheim & Kaplan, 2019). The complexity of machine-learning systems can further make it difficult for affected individuals to understand how decisions are generated, contributing to concerns about algorithmic opacity and the so-called "black box" problem (Tschider, 2020).

Algorithmic bias represents an additional ethical challenge. Bias can arise from training data, model design, assumptions embedded within datasets, or the contexts in which systems are deployed. Consequently, AI systems can reproduce or amplify existing social inequalities rather than eliminate them (Keles, 2023; Lewis, 2024).

These challenges demonstrate that ethical AI cannot be understood solely as a technical problem. Questions of governance, social context, power, and institutional responsibility are equally important.

2.2 Indigenous data sovereignty

Indigenous data sovereignty emphasizes Indigenous authority over data relating to Indigenous peoples and communities. It is closely associated with Indigenous self-determination and governance because data can influence political representation, public policy, resource management, research priorities, and economic development (Kukutai & Taylor, 2016; Kukutai et al., 2020).

The importance of data sovereignty is particularly apparent when external institutions collect information concerning Indigenous communities and subsequently determine how that information is stored, interpreted, or distributed. Data governance can therefore become an extension of broader relationships of power.

Indigenous data sovereignty offers a means of addressing these asymmetries by strengthening Indigenous decision-making regarding data. Rather than viewing communities simply as sources of information, the approach recognizes them as legitimate authorities and governance actors.

2.3 Indigenous knowledge and AI

Indigenous knowledge encompasses diverse systems of knowledge developed through relationships between communities and their environments. Barnhardt and Kawagley (2005) demonstrate that Indigenous knowledge systems involve distinctive ways of knowing and interpreting relationships between humans and the natural world.

The potential contribution of Indigenous knowledge to sustainability has received increasing attention. Mazzocchi (2020) argues that Indigenous knowledge can contribute to deeper understandings of sustainability, while Jamieson (2010) emphasizes the role of Indigenous communities in sustainability-oriented environmental governance.

AI can potentially support Indigenous knowledge preservation and application. Digital technologies have, for example, been explored as mechanisms for preserving and promoting Indigenous languages (Ajani et al., 2024), while generative AI has been examined for culturally relevant storytelling and Native language learning (Nanduri, 2024).

However, digitization also introduces risks. Transforming culturally embedded knowledge into machine-readable datasets can separate information from the cultural protocols governing its appropriate use. Some forms of knowledge may be restricted, sacred, community-specific, or subject to particular cultural responsibilities. Consequently, technological accessibility should not automatically be interpreted as authorization for unrestricted AI use.

2.4 Decolonizing AI governance

Decolonizing AI governance requires critical examination of whose knowledge, values, assumptions, and institutional structures shape AI systems. Ayana et al. (2024) emphasize the importance of examining AI

governance through decolonial perspectives, particularly in regions where existing governance models may not adequately reflect local contexts.

Lehuedé (2023) similarly draws attention to colonial patterns within data-intensive scientific collaboration, demonstrating how unequal knowledge relationships can persist within technologically advanced research environments. These observations are relevant to AI because data-intensive technologies can reproduce asymmetrical relationships between knowledge producers, data subjects, researchers, and technology developers.

Indigenous protocols for AI can therefore provide practical mechanisms for incorporating culturally grounded governance into technological development (Abdilla et al., 2021). Munn (2024), for example, discusses the evaluation of AI through Māori principles, demonstrating how Indigenous values can contribute directly to the assessment of AI systems.

3. Methodology

This study adopts a narrative and thematic review methodology to examine the intersection of AI ethics and Indigenous data sovereignty.

3.1 Review approach

Relevant peer-reviewed research, scholarly books, international policy documents, institutional reports, Indigenous-led data governance frameworks, and authoritative publications were considered. The review focused on literature addressing:

1. AI ethics and responsible AI;
2. Indigenous data sovereignty;
3. Indigenous data governance;
4. Indigenous knowledge and digital technologies;
5. algorithmic bias and discrimination;
6. data privacy and collective rights;
7. Indigenous participation in technological development; and
8. AI and sustainable development.

3.2 Literature identification

Relevant literature can be identified through major academic databases and search platforms, including multidisciplinary scholarly databases. Search terms may include combinations of *artificial intelligence*, *AI ethics*, *Indigenous data sovereignty*, *Indigenous data governance*, *Indigenous knowledge*, *algorithmic bias*, *responsible AI*, *data justice*, *digital sovereignty*, and *sustainable development*.

3.3 Inclusion and exclusion criteria

Literature was considered relevant when it addressed ethical, governance, technological, social, cultural, or sustainability dimensions of AI and/or Indigenous data. Publications lacking substantive relevance to AI, data governance, Indigenous rights, or related ethical issues were excluded.

3.4 Thematic analysis

The selected literature was examined thematically. Major themes were organized around:

- data ownership and control;
- consent and community participation;
- privacy and collective rights;
- algorithmic bias;
- Indigenous knowledge protection;
- accountability and transparency;
- benefit sharing;
- Indigenous governance;
- digital inclusion; and

- sustainable development.

The findings were subsequently synthesized to develop a conceptual framework linking responsible AI with Indigenous data sovereignty

4. Challenges at the Intersection of AI and Indigenous Data

4.1 Data extraction and historical inequalities

One of the most significant concerns is the continuation of extractive approaches to Indigenous data. Historically, Indigenous knowledge and resources have frequently been incorporated into external research and institutional systems without equivalent recognition of Indigenous authority or benefit. Contemporary data-intensive technologies can reproduce these patterns when Indigenous data are collected and subsequently processed outside community governance structures (Kukutai & Taylor, 2016; Lehuedé, 2023).

AI can intensify this problem because information initially collected for one purpose may subsequently be reused for algorithmic training, predictive modelling, commercial applications, or other purposes. Such secondary uses raise questions concerning authorization, accountability, and benefit sharing.

4.2 Consent and collective decision-making

Conventional research ethics frequently emphasize individual informed consent. Indigenous data governance can require a broader conception of consent because information may possess collective cultural, social, historical, or territorial significance (Kukutai et al., 2020).

An individual providing information may not necessarily possess authority to authorize the commercialization or AI-based processing of collectively held cultural knowledge. Consequently, AI governance involving Indigenous data should consider community-level authority alongside individual consent.

4.3 Algorithmic bias and representation

AI systems trained on incomplete or non-representative datasets can produce biased outcomes. Bias becomes especially problematic when Indigenous populations are underrepresented in datasets or when externally developed categories fail to adequately reflect Indigenous identities and social structures (Keles, 2023; Lewis, 2024).

Bias may emerge at multiple stages, including data collection, annotation, model development, deployment, and interpretation. Addressing it therefore requires continuous assessment rather than a single technical correction.

Indigenous perspectives can contribute to this process by challenging assumptions embedded within datasets and algorithms. Munn (2024) demonstrates the value of evaluating AI systems according to Māori principles, while Habash (2024) highlights *Two-Eyed Seeing* as an ethical space through which Indigenous and Western approaches can interact in engineering and computing education.

4.4 Commercialization of Indigenous knowledge

AI creates new possibilities for extracting value from large collections of cultural, linguistic, environmental, and ecological information. If Indigenous knowledge is incorporated into commercial AI systems without appropriate authorization or benefit sharing, communities may lose control over culturally significant resources.

This concern is consistent with broader critiques of data-centric AI, in which the benefits of data-driven innovation may be unevenly distributed while risks are disproportionately experienced by data subjects (Patel, 2024). Indigenous data sovereignty provides a framework for addressing this imbalance by emphasizing community authority and benefit.

4.5 Privacy and collective rights

Privacy frameworks frequently conceptualize information as belonging primarily to identifiable individuals. Indigenous data can have implications that extend beyond individuals to families, communities, nations, territories, and cultural groups.

AI systems capable of linking multiple datasets may increase these risks by enabling inferences that were not apparent in individual datasets. Concerns regarding AI, privacy, and democracy therefore have particular relevance when applied to communities whose data may carry collective significance (Manheim & Kaplan, 2019).

5. Indigenous Data Governance Principles for Ethical AI

5.1 Indigenous authority

Indigenous communities should have meaningful authority over decisions concerning AI projects from their earliest stages. This approach is consistent with the broader principles of Indigenous self-determination and governance (Kukutai & Taylor, 2016; Kuokkanen, 2019).

Meaningful authority extends beyond consultation. Indigenous institutions and governing bodies should have appropriate opportunities to determine whether data should be collected, which uses are acceptable, and under what conditions external organizations may access or process data.

5.2 Collective benefit

AI projects involving Indigenous data should generate tangible and appropriately distributed benefits for participating communities. Benefit should not be restricted to academic publications or commercial products produced outside the community.

The principle of reciprocity is consistent with Indigenous approaches emphasizing relationships and responsibilities rather than purely transactional interactions (Kawharu, 2000; Paul-Burke & Rameka, 2015).

5.3 Responsibility

Organizations using Indigenous data should recognize long-term responsibilities toward communities. This requires institutions to consider the consequences of data use beyond the immediate objectives of a research project or technological application.

Such an approach is compatible with Indigenous concepts of guardianship and responsibility, particularly the Māori principle of *kaitiakitanga*, which emphasizes active guardianship and relationships with the world (Kawharu, 2000; Paul-Burke & Rameka, 2015).

5.4 Ethics and cultural protocols

Ethical AI involving Indigenous communities should incorporate community-defined cultural protocols. Abdilla et al. (2021) emphasize the importance of Indigenous protocols for AI, while Munn (2024) demonstrates the potential for Indigenous principles to serve as criteria for evaluating AI systems.

This approach recognizes that ethical principles cannot always be separated from cultural context. What constitutes appropriate data access, knowledge sharing, representation, and technological intervention may vary between communities.

6. Proposed Framework for Inclusive and Sustainable AI Development

A framework integrating AI ethics and Indigenous data sovereignty can be organized around seven interconnected pillars.

6.1 Indigenous leadership and governance

Indigenous representatives should participate meaningfully in AI projects from conception through implementation and evaluation. Indigenous governance should not be treated as an optional consultation stage.

This principle is consistent with Indigenous self-determination and governance scholarship (Kukutai & Taylor, 2016; Kuokkanen, 2019) and with emerging approaches to Indigenous AI protocols (Abdilla et al., 2021).

6.2 Sovereign data stewardship

Data should be governed according to community-defined rules concerning collection, storage, access, sharing, retention, and destruction. Indigenous data sovereignty provides the conceptual foundation for such governance (Kukutai & Taylor, 2016; Kukutai et al., 2020).

Data stewardship should also consider the environmental and material dimensions of digital infrastructures. Lehuedé (2024b) highlights the significance of water and environmental resources within AI's value chain, suggesting that ethical AI must account for ecological as well as informational resources.

6.3 Culturally appropriate consent

Consent mechanisms should recognize collective rights and cultural protocols in addition to individual consent. Researchers and developers should establish clear processes through which Indigenous governing bodies can determine appropriate data uses.

This approach can help prevent situations in which technically valid individual consent results in culturally inappropriate collective data use.

6.4 Algorithmic fairness

AI systems should be evaluated for bias, representational limitations, discriminatory outcomes, and inappropriate categorization of Indigenous populations (Keles, 2023; Lewis, 2024).

Evaluation should incorporate Indigenous perspectives rather than relying exclusively on externally defined technical measures of fairness. Munn's (2024) discussion of Māori principles illustrates how culturally grounded evaluation criteria can complement conventional AI assessment.

6.5 Transparency and accountability

Developers and institutions should clearly communicate how Indigenous data are collected, processed, used, shared, and potentially commercialized. Transparency should extend beyond technical explanations of algorithms to include institutional relationships and data governance arrangements. This is particularly important because opaque AI systems can make it difficult to determine how decisions are produced or challenged (Tschider, 2020).

6.6 Equitable benefit sharing

Where Indigenous data contribute to research, AI systems, commercial products, or economic value, mechanisms should exist to ensure fair and meaningful benefit sharing.

Benefit sharing can include financial returns, employment, infrastructure, technical capacity building, community-controlled datasets, educational opportunities, and access to resulting technologies.

6.7 Sustainability and intergenerational responsibility

AI governance should consider long-term cultural, environmental, social, and economic consequences. Indigenous perspectives can strengthen sustainability by emphasizing relationships among people, ecosystems, knowledge, and future generations (Jamieson, 2010; Mazzocchi, 2020). The concept of *kaitiakitanga* offers an especially relevant model because it emphasizes active guardianship and responsibility toward the environment (Kawharu, 2000; Paul-Burke & Rameka, 2015). Similar principles can inform AI applications in environmental monitoring and resource management.

7. AI, Indigenous Rights, and Sustainable Development

AI has potential to contribute positively to Indigenous communities when technological priorities are community-driven. Potential applications include Indigenous language preservation, environmental monitoring, biodiversity conservation, climate adaptation, healthcare, education, and sustainable resource management.

Digital technologies have already been identified as potentially important tools for Indigenous language preservation and promotion (Ajani et al., 2024). Generative AI may further contribute to culturally relevant storytelling and language learning, provided that communities retain appropriate control over linguistic datasets and cultural content (Nanduri, 2024).

Environmental applications provide another promising area. AI-assisted monitoring can process large volumes of ecological information and support conservation and resource management. AI applications in forestry, for example, have been associated with opportunities for monitoring, management, and conservation (Asif et al., 2023). Indigenous knowledge can complement such technological systems by contributing place-based ecological understanding.

The development of environmental intelligence platforms for Māori agribusiness collectives and iwi provides an example of how automated sensor networks can be designed around Indigenous environmental information needs (Reid et al., 2023). Such approaches illustrate the possibility of developing technological infrastructure in response to community-defined priorities rather than imposing external technological objectives.

AI may also contribute to broader models of social and ecological well-being. Concepts such as *Buen vivir* emphasize living well through relationships between individuals, communities, and their environments, offering an alternative perspective on development and well-being (Mero-Figueroa et al., 2020).

However, technological intervention should not automatically be equated with development. Sustainable development requires social justice, cultural continuity, participation, and self-determination. Indigenous pedagogies and knowledge systems can contribute to alternative understandings of sustainable futures that move beyond purely economic or technological indicators (Carpena-Méndez et al., 2022).

7.1 Digital sovereignty and ecological responsibility

Digital sovereignty is increasingly connected with questions of political autonomy and control over technological infrastructures. Lehuedé (2024a) discusses digital sovereignty through a decolonial perspective, while Lehuedé (2024b) draws attention to the environmental resources embedded within AI value chains.

This broader perspective suggests that Indigenous data sovereignty should not be isolated from questions of digital infrastructure, energy use, water consumption, hardware production, and environmental sustainability. Responsible AI must therefore account for both informational sovereignty and material ecological consequences.

7.2 Indigenous perspectives and alternative forms of intelligence

The dominant conception of AI frequently assumes that intelligence can be represented through computational models. Indigenous perspectives can challenge this assumption by recognizing multiple forms of knowledge and intelligence.

Silano (2024) argues for consideration of Indigenous perspectives in adopting AI technologies, while Habash (2024) emphasizes *Two-Eyed Seeing* as an approach for creating an ethical space of engagement between different knowledge traditions.

Such approaches can support a more pluralistic understanding of intelligence in which technological systems complement rather than displace Indigenous knowledge systems.

8. Barriers to Implementation

8.1 Limited technological infrastructure

Some Indigenous communities experience limitations in connectivity, computing infrastructure, digital services, and access to technological resources. These inequalities can restrict participation in AI development and governance.

Digital inclusion therefore represents an essential component of Indigenous data sovereignty. Without access to appropriate infrastructure, communities may remain dependent on external institutions for data storage, computational processing, and technological development.

8.2 Capacity constraints

Communities may require additional technical, legal, and institutional capacity to participate effectively in AI governance. Capacity building should therefore form part of AI partnerships rather than being treated as a separate activity. Education and training can help Indigenous communities participate in data management, algorithmic evaluation, software development, cybersecurity, and technological governance.

8.3 Power asymmetries

Universities, governments, and technology companies may possess substantially greater financial, technological, and legal resources than Indigenous institutions. Such asymmetries can affect negotiations concerning data access and research partnerships.

The decolonial AI governance literature emphasizes the importance of recognizing these structural differences rather than assuming that all stakeholders participate from equal positions (Ayana et al., 2024; Lehuedé, 2023).

8.4 Fragmented regulatory systems

Existing privacy, intellectual property, research ethics, and data protection frameworks may not adequately address collective Indigenous rights. Conventional regulatory approaches can prioritize individual ownership or institutional control without sufficiently recognizing collective cultural interests. AI governance therefore requires coordination between technological regulation and Indigenous rights frameworks.

8.5 Limited Indigenous representation

Indigenous peoples remain underrepresented in many areas of AI research, engineering, policy, and governance. Increasing representation is important because participation can influence research priorities, technical design, evaluation criteria, and institutional practices.

Indigenous participation should extend beyond consultation to include leadership, employment, research collaboration, education, and decision-making authority.

8.6 Commercial pressures

Commercial incentives can encourage organizations to prioritize data access and technological development over community control. Data-driven AI economies may therefore create incentives for extensive data collection.

Strong governance mechanisms are needed to ensure that commercial interests do not override Indigenous rights and cultural protocols.

9. Discussion

The reviewed literature indicates that AI ethics and Indigenous data sovereignty share several important objectives, including fairness, accountability, privacy, participation, and protection from harm. Nevertheless, Indigenous data sovereignty introduces a broader understanding of data governance by emphasizing collective rights, cultural authority, self-determination, and relationships between knowledge and community (Kukutai & Taylor, 2016; Kukutai et al., 2020).

A major limitation of conventional AI ethics is its tendency to focus on individual users and abstract principles. Principles such as fairness, transparency, and accountability are important, but they may not adequately address a prior question: who possesses the authority to decide whether particular data should be used in the first place?

Indigenous data sovereignty shifts the focus from merely asking whether data processing is technically or procedurally ethical to asking whether the community has legitimate authority over that processing. This represents an important expansion of conventional AI governance.

The issue of consent illustrates this distinction. An individual-centered model may regard informed consent as sufficient for data collection, whereas Indigenous governance may recognize that some information has collective cultural significance (Kukutai et al., 2020). AI governance involving Indigenous communities therefore needs mechanisms capable of recognizing both individual rights and collective authority.

The integration of Indigenous perspectives can also strengthen the sustainability dimension of AI governance. Indigenous approaches to sustainability frequently emphasize relationships, responsibilities, stewardship, reciprocity, and long-term ecological continuity (Jamieson, 2010; Mazzocchi, 2020). Māori *kaitiakitanga*, for instance, provides a framework centered on guardianship and responsibility toward the environment (Kawharu, 2000; Paul-Burke & Rameka, 2015).

These principles are particularly relevant to AI because AI systems have material environmental footprints. Data centers, computational infrastructure, hardware production, and cooling systems consume energy and natural resources. Lehuedé (2024b) draws attention to water within AI's value chain, demonstrating that ethical AI must consider the environmental resources supporting computational systems.

The review also indicates that Indigenous participation should not be reduced to consultation. Meaningful participation requires decision-making power, institutional representation, technical expertise, and mechanisms for equitable benefit sharing. Indigenous communities should therefore be positioned as partners and governance actors rather than merely sources of data.

Emerging examples demonstrate the practical potential of this approach. Indigenous language preservation through digital technologies illustrates how AI and related tools can support cultural continuity when technological development is aligned with community priorities (Ajani et al., 2024; Nanduri, 2024). Similarly, Kaitiaki Intelligence Platforms demonstrate how automated environmental sensing can be developed around the environmental intelligence needs of Māori collectives and iwi (Reid et al., 2023).

The role of Indigenous protocols is equally important. Abdilla et al. (2021) demonstrate the relevance of Indigenous protocols to AI, while Munn (2024) proposes evaluating AI according to Māori principles. These approaches challenge the assumption that AI ethics must be defined exclusively through universalized technological or philosophical principles.

The concept of *Two-Eyed Seeing* provides another useful model because it creates an ethical space in which Indigenous and Western knowledge systems can interact without requiring one system to replace the other (Habash, 2024). This approach may be particularly useful for interdisciplinary AI research involving environmental science, engineering, Indigenous knowledge, and sustainability.

The proposed framework consequently views ethical AI as a socio-technical governance challenge rather than solely a problem of algorithm design. Technical safeguards such as bias testing, privacy protection, explainability, and security remain necessary (Keles, 2023; Patel, 2024; Tschider, 2020). However, they should operate alongside community governance, cultural protocols, accountability mechanisms, and Indigenous authority.

A further implication concerns the meaning of sustainable development itself. Conventional technological development often evaluates success using measures such as productivity, efficiency, economic growth, or technological adoption. Indigenous and community-centered perspectives suggest that sustainability should also consider cultural continuity, ecological integrity, collective well-being, and intergenerational responsibility (Carpena-Méndez et al., 2022; Mero-Figueroa et al., 2020).

AI therefore has the potential either to reproduce existing inequalities or to contribute to more inclusive development. The difference depends substantially on governance. Where communities have meaningful authority over data and technological decisions, AI can support language preservation, environmental monitoring, education, and community-defined development. Where data are extracted without meaningful governance, AI may reinforce existing forms of technological and epistemic inequality.

10. Future Directions

Future research should investigate how Indigenous data sovereignty principles can be operationalized across different AI applications and legal contexts. Particular attention should be given to Indigenous-controlled AI datasets and data repositories, community-owned digital infrastructure, Indigenous language technologies, AI applications for climate adaptation and biodiversity conservation, culturally appropriate algorithmic auditing, collective consent mechanisms, Indigenous intellectual and cultural property protection, equitable models for commercial benefit sharing, and community-defined evaluation frameworks.

Research should also examine how Indigenous data governance can be incorporated into emerging AI regulatory systems. Comparative studies could investigate how different Indigenous nations and communities establish governance mechanisms according to their own legal, cultural, and institutional contexts.

Another important research direction concerns the development of Indigenous-led AI education and workforce initiatives. Increasing Indigenous representation in AI research, engineering, data science, and policy could help ensure that technological development reflects a wider range of knowledge systems and community priorities.

Future studies should prioritize Indigenous-led research methodologies and ensure that Indigenous scholars, knowledge holders, institutions, and communities are involved throughout the research lifecycle.

11. Conclusion

Artificial intelligence offers significant opportunities for advancing inclusive and sustainable development, but these opportunities cannot be realized equitably without addressing questions of data ownership, governance, cultural rights, and self-determination. Indigenous communities face distinctive risks because AI systems can transform culturally significant information into datasets that may be accessed, analyzed, reproduced, or commercialized outside community control.

Indigenous data sovereignty provides an important foundation for addressing these challenges. Its emphasis on Indigenous authority, collective rights, responsibility, ethics, and community benefit complements established principles of responsible AI while introducing a stronger focus on self-determination and cultural context.

A genuinely inclusive AI ecosystem should therefore move beyond the principles of *data about Indigenous peoples* toward data governed with and by Indigenous peoples**.** Indigenous leadership, culturally appropriate consent, sovereign data stewardship, algorithmic fairness, transparency, accountability, equitable benefit sharing, and intergenerational sustainability should be integrated throughout the AI lifecycle.

Ultimately, ethical AI should not be measured solely by whether an algorithm is accurate, efficient, or technically transparent. Its legitimacy should also depend on who controls the data, who makes decisions, whose knowledge is represented, who benefits, and whether technological development strengthens rather than undermines community sovereignty**.** Integrating Indigenous data sovereignty into AI governance can consequently provide a pathway toward technology that is not only innovative, but also culturally respectful, socially just, and sustainable.

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Role of Indigenous Women in Biodiversity Conservation: An Intergenerational Knowledge Transfer Study

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Abstract: Indigenous women play a critical yet frequently underrecognized role in biodiversity conservation through their intimate relationships with ecosystems, traditional livelihoods, food systems, medicinal practices, and cultural knowledge. Their knowledge encompasses the identification and sustainable use of plants and animals, seed selection and preservation, traditional agriculture, water management, forest-resource utilization, medicinal plant preparation, and ecological indicators transmitted across generations. This review examines the role of Indigenous women in biodiversity conservation, with particular emphasis on intergenerational knowledge transfer and the factors influencing the continuity of Indigenous ecological knowledge. A narrative and thematic review of peer-reviewed literature, books, reports, and relevant institutional publications was undertaken to synthesize evidence concerning Indigenous women, traditional ecological knowledge, biodiversity management, cultural practices, gendered knowledge systems, and intergenerational transmission. The review identifies Indigenous women as knowledge holders, educators, resource managers, custodians of food and medicinal biodiversity, and important participants in community-based conservation. Intergenerational knowledge transfer occurs through observation, participation, storytelling, oral traditions, household practices, rituals, seasonal activities, and learning through direct engagement with landscapes. However, this transmission is increasingly affected by environmental degradation, biodiversity loss, climate change, land-use transformation, migration, formal educational systems, socioeconomic pressures, cultural change, and declining access to traditional territories. The review further highlights gender-specific barriers that can limit recognition of women's knowledge within conservation policies and institutions. Strengthening Indigenous women's participation, supporting community-controlled knowledge systems, promoting intergenerational learning, and recognizing Indigenous rights can contribute to biodiversity conservation while maintaining cultural continuity. Integrating Indigenous women's knowledge with inclusive conservation strategies may therefore provide a pathway toward ecologically sustainable, culturally appropriate, and socially equitable biodiversity governance.

Keywords: Indigenous women; biodiversity conservation; traditional ecological knowledge; intergenerational knowledge; Indigenous communities

1. Introduction

Biodiversity provides the ecological foundation for human well-being, food security, livelihoods, cultural identity, and ecosystem resilience. The Convention on Biological Diversity (CBD) recognizes the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising from the utilization of genetic resources as interconnected objectives (Convention on Biological Diversity, 1992, Arts. 1 & 3). The definition of biological diversity under the CBD also recognizes diversity at genetic, species, and ecosystem levels, demonstrating that biodiversity conservation extends beyond the protection of individual species (Convention on Biological Diversity, 1992, Art. 2).

Indigenous peoples have maintained complex relationships with biological resources through long-term interaction with forests, agricultural landscapes, water systems, and other ecosystems. Their ecological knowledge frequently includes detailed understandings of plant and animal species, seasonal cycles, environmental indicators, resource availability, agricultural practices, and sustainable harvesting. The

CBD specifically recognizes the importance of respecting, preserving, and maintaining the knowledge, innovations, and practices of Indigenous and local communities relevant to biodiversity conservation and sustainable use (Convention on Biological Diversity, 1992, Art. 8[j]).

Within these knowledge systems, Indigenous women often occupy important but insufficiently recognized positions. Ecofeminist scholarship has emphasized the relationship between women's experiences, ecological sustainability, and systems of social and environmental domination (Mies & Shiva, 1993; Shiva, 1988). In the Indian context, historical relationships between communities, land, forests, and ecological resources further demonstrate that environmental knowledge is closely connected with social organization and resource access (Gadgil & Guha, 1992).

Indigenous and rural women frequently contribute to seed selection, food preparation, gathering of wild plants, medicinal-resource management, household nutrition, water collection, horticulture, and agricultural activities. Their ecological knowledge is often developed through repeated interaction with local ecosystems and transmitted through practical experience. Agarwal (1992) highlighted the importance of gender in agricultural knowledge systems, while her later work emphasized the relationship between gender and participation in environmental governance (Agarwal, 2010).

The conservation of traditional knowledge has also become an important legal and policy issue. International and national frameworks increasingly recognize the importance of protecting traditional knowledge and ensuring fair benefit sharing from biological and genetic resources (Biological Diversity Act, 2002; Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits, 2010). Nevertheless, the experiences associated with biopiracy demonstrate that knowledge held by Indigenous and local communities can be appropriated through intellectual property and commercial systems without adequate recognition or benefit sharing (Dutfield, 2004; Robinson, 2010; Shiva, 1997).

Intergenerational knowledge transfer is particularly important because biodiversity-related knowledge is not preserved solely through written documentation. It is often learned through participation in agriculture, gathering, food preparation, seed conservation, medicinal practices, oral traditions, and other everyday activities. Indigenous women can therefore function simultaneously as knowledge holders, practitioners, educators, and custodians of biodiversity.

This review examines the role of Indigenous women in biodiversity conservation, focusing on intergenerational knowledge transfer, traditional ecological knowledge, legal and institutional frameworks, gendered dimensions of conservation, challenges related to intellectual property and biopiracy, and strategies for strengthening Indigenous women's participation in biodiversity governance.

2. Indigenous Knowledge and Biodiversity Conservation

Indigenous knowledge systems represent dynamic bodies of knowledge developed through continued interaction between communities and their environments. Such knowledge may include information about species behavior, plant properties, seasonal changes, agricultural cycles, soil conditions, water resources, and ecological relationships. The CBD recognizes that the knowledge, innovations, and practices of Indigenous and local communities can be relevant to the conservation and sustainable use of biological diversity (Convention on Biological Diversity, 1992, Art. 8[j]).

Traditional ecological knowledge should not be understood merely as a collection of biological facts. It is frequently embedded within social practices, cultural values, livelihoods, and systems of responsibility. Gadgil and Guha (1992) demonstrated the importance of examining ecological history in relation to social and community relationships with land and natural resources.

Grassroots innovation also demonstrates how knowledge can emerge through local problem-solving and community experience. Gupta (2008) emphasized the significance of grassroots innovations and traditional knowledge, particularly in relation to locally developed practices and knowledge systems.

Biodiversity conservation can therefore benefit from approaches that recognize communities not simply as resource users but as knowledge holders and active contributors to environmental stewardship. The legal recognition of biodiversity and community knowledge in India reflects this broader perspective through the Biological Diversity Act, 2002, which provides an institutional framework concerning biodiversity conservation, sustainable use, and benefit sharing (Biological Diversity Act, 2002).

3. Indigenous Women as Custodians of Biodiversity

3.1 Traditional food systems and ecological knowledge

Indigenous women frequently contribute to the maintenance of diverse food systems through their knowledge of edible plants, fruits, seeds, roots, tubers, and other locally available biological resources. Knowledge about the identification, collection, processing, storage, and seasonal availability of these resources can contribute to both biodiversity conservation and household food security.

Shiva (1988) emphasized the connection between women, ecology, and development, particularly the importance of recognizing women's relationships with natural resources. These relationships can generate detailed practical knowledge concerning local ecosystems.

3.2 Seed conservation and agricultural biodiversity

Women often play important roles in selecting, preserving, storing, and exchanging seeds. These practices can contribute to maintaining agricultural biodiversity and locally adapted crop varieties. Gendered agricultural knowledge therefore represents an important dimension of biodiversity conservation (Agarwal, 1992).

The Protection of Plant Varieties and Farmers' Rights Act, 2001, recognizes farmers' rights, including provisions relevant to the conservation and use of plant varieties (Protection of Plant Varieties and Farmers' Rights Act, 2001, § 39). Such recognition is important because traditional farming practices can contribute to the maintenance of genetic diversity.

The Basmati Rice Case further illustrates the importance of protecting agricultural resources and associated knowledge from inappropriate claims and commercial appropriation (RiceTec Inc. v. Union of India, 1997).

3.3 Medicinal plant knowledge

Indigenous women frequently possess detailed knowledge regarding medicinal plants and traditional methods of preparation. Such knowledge may include plant identification, appropriate harvesting periods, plant parts used, methods of processing, and culturally appropriate practices of use.

Traditional medicinal knowledge has also been a significant area of concern in debates regarding intellectual property and biopiracy. The Turmeric Patent Case is frequently associated with challenges concerning the recognition of prior traditional knowledge in patent systems (Council of Scientific & Industrial Research v. Union of India, 1997). The establishment of the Traditional Knowledge Digital Library has further been associated with efforts to document traditional knowledge and prevent inappropriate patent claims based on existing knowledge (Traditional Knowledge Digital Library, n.d.).

However, documentation must be approached carefully. Correa (2003) and Dutfield (2004) emphasized broader concerns regarding the protection of traditional knowledge within intellectual property systems. Documentation can support defensive protection, but it should not result in unrestricted access to culturally sensitive knowledge.

3.4 Forest and natural-resource management

Women may contribute to sustainable forest-resource management through their involvement in gathering fruits, medicinal plants, fibers, fodder, and other biological resources. Their repeated interaction with local environments can provide detailed knowledge of species availability and ecological change.

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, is important in this context because access to and relationships with forests are closely connected with the ability of forest-dependent communities to maintain traditional knowledge and resource practices.

4. Intergenerational Knowledge Transfer

4.1 Learning through participation

Indigenous knowledge is frequently transmitted through practical participation rather than exclusively through formal instruction. Children and younger community members may learn ecological knowledge while participating in farming, gathering, food preparation, seed selection, and other activities.

This form of learning helps maintain a relationship between knowledge and practice. Women's roles in household and agricultural activities can consequently create important opportunities for intergenerational transmission of ecological knowledge (Agarwal, 1992; Shiva, 1988).

4.2 Oral traditions and cultural transmission

Stories, oral histories, customary practices, and other cultural forms can communicate information about species, landscapes, resource-use practices, and ecological responsibilities. Knowledge transmission is therefore often inseparable from cultural continuity.

The protection of traditional knowledge consequently requires more than preserving isolated information. It requires attention to the communities and cultural systems through which knowledge is maintained and transmitted (Correa, 2003; Correa, n.d.).

4.3 Observation and experiential learning

Observation enables younger generations to learn through direct interaction with elders, landscapes, plants, agricultural systems, and community practices. Knowledge about biodiversity is often strengthened when learning occurs within the ecosystems to which the knowledge relates.

Gupta (2008) similarly highlighted the importance of locally developed knowledge and grassroots innovation, demonstrating that ecological and practical knowledge can emerge through experience and local problem-solving.

4.4 Intergenerational relationships and gender

The relationship between elders and younger generations is particularly important for maintaining ecological knowledge. Indigenous women can act as bridges between generations by transferring practical knowledge, cultural values, and environmental responsibilities.

Ecofeminist perspectives have drawn attention to the need to recognize women's environmental experiences and knowledge within broader systems of development and ecological governance (Mies & Shiva, 1993; Shiva, 1988).

5. Gender Dimensions of Indigenous Ecological Knowledge

Knowledge within Indigenous communities is not distributed uniformly. Gender, age, occupation, social responsibilities, and relationships with particular environments can influence the forms of knowledge individuals acquire.

Agarwal (1992) emphasized the gendered dimensions of agricultural knowledge, while Agarwal (2010) examined the importance of gender within environmental governance. These perspectives are particularly relevant to biodiversity conservation because excluding women from consultation and decision-making can result in the exclusion of significant ecological knowledge.

Indigenous women may possess specialized knowledge associated with seed management, food systems, medicinal plants, household gardens, gathering, and other activities. These distinctions should not be treated as universal, because gender roles differ considerably between Indigenous communities. Nevertheless, conservation research should actively examine whose knowledge is being recognized and whose participation is being sought.

Meaningful participation also requires more than representation. Women should have opportunities to influence conservation priorities, biodiversity management, access and benefit-sharing arrangements, and institutional decisions.

6. Legal Protection, Traditional Knowledge, and Biodiversity Governance

6.1 International biodiversity governance

The CBD provides an important international framework for biodiversity conservation, sustainable use, and benefit sharing (Convention on Biological Diversity, 1992, Arts. 1 & 3). Article 8(j) is particularly relevant because it recognizes the importance of Indigenous and local communities' knowledge, innovations, and practices in biodiversity conservation (Convention on Biological Diversity, 1992, Art. 8[j]).

The Nagoya Protocol further addresses access to genetic resources and the fair and equitable sharing of benefits arising from their utilization (Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits, 2010). Morgera (2015) examined the broader significance of the Nagoya Protocol and its implications for international biodiversity governance.

For Indigenous women, access and benefit-sharing frameworks are important because women's knowledge and practices may contribute directly to the identification, conservation, and use of biological resources. Benefit-sharing mechanisms should therefore recognize gendered knowledge contributions rather than assuming that benefits distributed through communities will automatically reach women.

6.2 Intellectual property and traditional knowledge

The relationship between traditional knowledge and intellectual property remains complex. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS, 1994, Art. 27) provides an important international legal framework concerning patentability and intellectual property. However, traditional knowledge may not fit easily within systems designed around individual inventorship, novelty, and time-limited ownership.

Correa (2003) and Dutfield (2004) examined the challenges associated with protecting traditional knowledge through conventional intellectual property frameworks. Robinson (2010) further discussed biopiracy and debates concerning the use of genetic resources and community knowledge.

The experiences associated with turmeric and neem demonstrate these concerns. The Turmeric Patent Case raised questions regarding patent claims involving knowledge already present within traditional practices (Council of Scientific & Industrial Research v. Union of India, 1997). Similarly, the Neem Patent Case became an important example in debates concerning biopiracy and the commercialization of traditional biological knowledge (W.R. Grace & Co. v. Neem Patent Case, 2000).

Shiva (1997) characterized such processes within the broader framework of biopiracy, emphasizing concerns regarding the appropriation of nature and knowledge.

6.3 National biodiversity governance in India

The Biological Diversity Act, 2002, provides a significant legal framework for biodiversity governance in India. Its objectives and institutional approach connect biodiversity conservation with sustainable use and benefit sharing (Biological Diversity Act, 2002, preamble).

The Act also provides institutional mechanisms relevant to biodiversity governance, including authorities and local-level structures such as Biodiversity Management Committees (Biological Diversity Act, 2002, §§ 8, 22, 41). Operational guidance for Biodiversity Management Committees has further been developed through national institutional guidelines (Ministry of Environment, Forest and Climate Change, 2013).

Access and benefit sharing is particularly relevant to Indigenous and local communities whose knowledge contributes to the utilization of biological resources. Section 21 of the Biological Diversity Act addresses benefit-sharing arrangements (Biological Diversity Act, 2002, § 21), while scholarship has emphasized the importance of understanding access and benefit sharing through the experiences and histories of

communities themselves (Bavikatte & Robinson, 2011). The decision in *Divya Pharmacy v. Union of India* (2018) is also relevant to debates surrounding benefit sharing and the use of biological resources within India.

6.4 Traditional knowledge documentation

The Traditional Knowledge Digital Library represents an important institutional approach to documenting Indian traditional knowledge and strengthening defensive protection against inappropriate patent claims (Traditional Knowledge Digital Library, n.d.).

Nevertheless, documentation should not be considered a complete substitute for community control. Recording knowledge in databases can create new questions regarding access, authority, confidentiality, and cultural sensitivity. Effective protection therefore requires a balance between preventing misappropriation and respecting the rights of communities to control their knowledge.

7. Biopiracy, Benefit Sharing, and Indigenous Women's Knowledge

Biopiracy refers broadly to concerns surrounding the appropriation or commercialization of biological resources and associated knowledge without appropriate authorization or benefit sharing. Shiva (1997) drew attention to the relationship between biological resources, knowledge, and systems of appropriation. The Turmeric and Neem cases became important examples within debates concerning the limitations of conventional intellectual property systems in recognizing traditional knowledge (Council of Scientific & Industrial Research v. Union of India, 1997; W.R. Grace & Co. v. Neem Patent Case, 2000). The Basmati case similarly illustrates concerns surrounding commercial claims associated with biological and agricultural resources (RiceTec Inc. v. Union of India, 1997).

These issues have particular implications for Indigenous women because knowledge associated with medicinal plants, food resources, seeds, and biodiversity may be transmitted and maintained through women's everyday practices. If such knowledge is extracted without recognizing women as knowledge holders, both gender inequality and knowledge injustice can be reinforced.

The Nagoya Protocol established an important framework for fair and equitable benefit sharing (Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits, 2010). Within India, the Biological Diversity Act provides a national basis for access and benefit-sharing arrangements (Biological Diversity Act, 2002, § 21).

However, equitable benefit sharing requires attention to who actually receives benefits. Community-level agreements should not automatically assume that all members have equal decision-making power or access to benefits. Gender-responsive approaches are therefore necessary to ensure that Indigenous women's knowledge and contributions are appropriately recognized.

8. Community-Based Conservation and Institutional Participation

Community-based biodiversity conservation can benefit substantially from the participation of Indigenous women. Their practical knowledge can contribute to the conservation of traditional crop varieties, sustainable harvesting, medicinal plants, household gardens, forest resources, and local food systems.

The Biological Diversity Act provides local institutional mechanisms through Biodiversity Management Committees, creating potential spaces for community participation in biodiversity governance (Biological Diversity Act, 2002, § 41; Ministry of Environment, Forest and Climate Change, 2013). However, the effectiveness of such mechanisms depends on whether women and marginalized knowledge holders are able to participate meaningfully.

Agarwal (2010) emphasized that gender is an important consideration in environmental governance. Applying this perspective to biodiversity institutions suggests that formal participation alone may be insufficient where social inequalities prevent women from influencing decisions.

The Forest Rights Act also provides an important context for community relationships with forest ecosystems. Secure recognition of forest-related rights can support the continuation of ecological practices and knowledge systems associated with forests (Scheduled Tribes and Other Traditional Forest Dwellers [Recognition of Forest Rights] Act, 2006).

Conservation governance should therefore recognize Indigenous women not merely as beneficiaries but as knowledge holders and decision-makers. Their involvement should extend to conservation planning, biodiversity documentation, resource monitoring, access and benefit-sharing arrangements, and institutional governance.

9. Threats to Intergenerational Knowledge Transfer

9.1 Biodiversity loss and environmental change

Biodiversity loss can contribute directly to knowledge loss. When particular plants, animals, habitats, or ecological practices disappear, opportunities to transmit associated knowledge can also decline. This creates a reciprocal relationship in which ecological degradation threatens cultural and knowledge diversity.

The CBD's objectives of biodiversity conservation and sustainable use are therefore also relevant to maintaining the ecological foundations upon which traditional knowledge depends (Convention on Biological Diversity, 1992, Arts. 1 & 3).

9.2 Land-use change and restricted access

Changes in land use and restricted access to forests, agricultural landscapes, and other traditional territories can reduce opportunities for direct learning. The Forest Rights Act is important because relationships with forests are closely linked with the ability of traditional forest-dwelling communities to continue ecological practices (Scheduled Tribes and Other Traditional Forest Dwellers [Recognition of Forest Rights] Act, 2006).

9.3 Intellectual property pressures and knowledge extraction

Traditional knowledge may be vulnerable to extraction and commercialization when legal and institutional systems fail to recognize collective knowledge rights. The concerns raised by the turmeric, neem, and other biopiracy debates demonstrate the potential consequences of such failures (Council of Scientific & Industrial Research v. Union of India, 1997; Robinson, 2010; W.R. Grace & Co. v. Neem Patent Case, 2000).

The establishment of documentation mechanisms such as the Traditional Knowledge Digital Library can provide defensive protection, but documentation should remain consistent with community interests and cultural protocols (Traditional Knowledge Digital Library, n.d.).

9.4 Gender inequality in knowledge recognition

Gender inequality can also threaten knowledge continuity. If women's ecological knowledge is undervalued within research, governance, or formal education, younger generations may receive the message that such knowledge has limited social value.

Agarwal's work on gender, agricultural knowledge, and green governance demonstrates the importance of recognizing women's contributions within environmental systems (Agarwal, 1992, 2010). Addressing gender inequality is therefore essential not only for social justice but also for preserving ecological knowledge diversity.

10. Opportunities for Strengthening Indigenous Women's Role

10.1 Community-controlled knowledge systems

Community-controlled approaches to knowledge documentation can help preserve ecological knowledge while ensuring that Indigenous communities retain authority over access and use. Such systems should

establish culturally appropriate rules concerning ownership, confidentiality, attribution, and benefit sharing.

The broader debates on traditional knowledge protection demonstrate that no single legal instrument can fully address all forms of knowledge and community interests (Correa, 2003; Dutfield, 2004).

10.2 Strengthening intergenerational learning

Programs that create opportunities for elders, women, and younger generations to participate together in farming, seed conservation, medicinal plant cultivation, biodiversity monitoring, and storytelling can strengthen knowledge continuity.

These activities can build upon the importance of practical learning and locally generated innovation identified in research on traditional knowledge and grassroots innovation (Gupta, 2008).

10.3 Gender-responsive benefit sharing

Benefit-sharing mechanisms should explicitly consider women's knowledge contributions. The Nagoya Protocol and India's access and benefit-sharing framework provide opportunities to strengthen equitable arrangements (Biological Diversity Act, 2002, § 21; Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits, 2010).

A gender-responsive approach should assess who participates in negotiations, who controls the distribution of benefits, and whether women knowledge holders receive meaningful recognition.

10.4 Strengthening institutional representation

Indigenous women's participation in Biodiversity Management Committees and other conservation institutions should be strengthened. Existing institutional guidelines can provide mechanisms for local biodiversity governance, but implementation should ensure meaningful rather than symbolic participation (Ministry of Environment, Forest and Climate Change, 2013).

10.5 Legal and ethical protection against biopiracy

The experiences associated with turmeric, neem, and other cases demonstrate the importance of protecting traditional knowledge against inappropriate claims (Council of Scientific & Industrial Research v. Union of India, 1997; RiceTec Inc. v. Union of India, 1997; W.R. Grace & Co. v. Neem Patent Case, 2000).

Protection should combine appropriate legal safeguards, documentation where communities consider it appropriate, recognition of collective interests, and fair benefit-sharing mechanisms.

11. Discussion

The reviewed evidence demonstrates that Indigenous women occupy an important position at the intersection of biodiversity conservation, traditional knowledge, and intergenerational learning. Their ecological knowledge is frequently connected with everyday practices involving food, seeds, medicinal plants, forests, and other biological resources. This supports the broader argument that biodiversity conservation cannot be separated completely from social relationships, livelihoods, cultural practices, and systems of knowledge.

The CBD's recognition of Indigenous and local knowledge under Article 8(j) provides an important international basis for acknowledging these contributions (Convention on Biological Diversity, 1992, Art. 8[j]). However, legal recognition alone does not ensure that women knowledge holders are equally represented in conservation institutions or benefit-sharing arrangements.

Gender scholarship demonstrates the importance of examining participation and power within environmental governance. Agarwal (2010) showed that governance structures must consider gendered inequalities, while her earlier work demonstrated that agricultural knowledge itself can be gender differentiated (Agarwal, 1992). These insights are particularly relevant to biodiversity policy because institutions that consult only selected community representatives may overlook substantial knowledge held by women.

Ecofeminist scholarship similarly provides a conceptual basis for examining the relationship between gender, ecology, and development. Shiva (1988) and Mies and Shiva (1993) emphasized the interconnected consequences of environmental degradation and social structures affecting women. While Indigenous communities are diverse and should not be represented through a single ecological or gendered experience, these perspectives highlight the importance of questioning whose environmental knowledge is recognized.

The review also demonstrates that intergenerational knowledge transfer is dependent upon continued interaction between people and ecosystems. Knowledge cannot always be preserved effectively by separating it from the practices and landscapes through which it is learned. Environmental degradation, land-use change, restricted access to forests, and biodiversity loss can therefore threaten both biological and knowledge diversity.

Legal frameworks relating to forests and biodiversity can influence these processes. The Forest Rights Act recognizes the importance of forest-related rights for eligible traditional forest-dwelling communities (Scheduled Tribes and Other Traditional Forest Dwellers [Recognition of Forest Rights] Act, 2006), while the Biological Diversity Act establishes mechanisms for conservation, biodiversity governance, and benefit sharing (Biological Diversity Act, 2002).

The relationship between biodiversity conservation and intellectual property represents another major challenge. Conventional intellectual property systems have often struggled to accommodate collective, intergenerational, and culturally embedded knowledge. The concerns examined by Correa (2003), Dutfield (2004), and Robinson (2010) demonstrate why traditional knowledge protection requires approaches extending beyond conventional patent frameworks.

The Turmeric and Neem cases remain important illustrations of these concerns (Council of Scientific & Industrial Research v. Union of India, 1997; W.R. Grace & Co. v. Neem Patent Case, 2000). The Basmati dispute further illustrates tensions surrounding biological resources, agricultural heritage, and commercial claims (RiceTec Inc. v. Union of India, 1997).

The development of the Traditional Knowledge Digital Library represents one response to the problem of inappropriate patent claims. However, documentation must be balanced against concerns regarding access and control. A database can prevent certain forms of misappropriation while potentially raising new questions about who determines what knowledge is made accessible (Traditional Knowledge Digital Library, n.d.).

Access and benefit sharing provides an additional opportunity to connect biodiversity governance with social equity. The Nagoya Protocol established an international framework emphasizing fair and equitable benefit sharing (Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits, 2010), while the Biological Diversity Act contains national provisions relating to benefit sharing (Biological Diversity Act, 2002, § 21). Scholarship on the history and practice of ABS has emphasized the importance of community-centered perspectives (Bavikatte & Robinson, 2011).

For Indigenous women, however, benefit sharing should be evaluated not only at the community level but also through attention to gendered power relations. It cannot be assumed that benefits reaching a community will automatically reach women whose knowledge contributed to resource identification or use.

The decision in *Divya Pharmacy v. Union of India* (2018) is relevant to ongoing debates regarding access to biological resources and benefit sharing within India's biodiversity governance framework. Such legal developments demonstrate the importance of maintaining mechanisms capable of linking commercial utilization with responsibilities toward biodiversity and knowledge holders.

Overall, the findings suggest that the conservation role of Indigenous women should be understood through an integrated framework. This framework connects biodiversity, traditional knowledge, gender equity, land and resource rights, legal protection, benefit sharing, and intergenerational learning. Effective

conservation should not merely extract women's knowledge for scientific or policy purposes. Instead, it should strengthen Indigenous women's authority, participation, recognition, and ability to transmit knowledge within their communities.

12. Future Research Directions

Future research should adopt more Indigenous-led, gender-responsive, and community-controlled approaches to examining biodiversity conservation. Important priorities include investigating women's contributions to seed and agricultural biodiversity, medicinal plant conservation, traditional food systems, forest-resource management, and ecological monitoring.

Further research is also needed on gender-specific pathways through which ecological knowledge is transferred between generations. Studies should examine how migration, biodiversity loss, land-use change, formal education, and economic transformation influence relationships between Indigenous women, elders, and younger generations.

Another important direction involves examining how legal frameworks concerning biodiversity, access and benefit sharing, intellectual property, and traditional knowledge operate in practice. Research should assess whether women knowledge holders participate meaningfully in Biodiversity Management Committees, benefit-sharing negotiations, and conservation decision-making.

Future studies should also investigate ethical models for community-controlled documentation and digital preservation of traditional knowledge. Such models should address confidentiality, cultural protocols, collective authority, access restrictions, attribution, and benefit sharing.

13. Conclusion

Indigenous women play a significant role in biodiversity conservation through their knowledge, practices, cultural responsibilities, and relationships with local ecosystems. Their contributions extend across traditional food systems, seed conservation, medicinal plants, agricultural biodiversity, forest resources, and ecological observation. They also play an important role in maintaining cultural continuity by transmitting environmental knowledge and responsibilities between generations.

Intergenerational knowledge transfer is strengthened when younger generations can learn through participation, observation, storytelling, cultural practices, and direct engagement with traditional landscapes. However, biodiversity loss, environmental degradation, restricted access to natural resources, land-use transformation, migration, socioeconomic pressures, and gender inequality can weaken these pathways.

Strengthening Indigenous women's leadership is therefore important for both biodiversity conservation and knowledge continuity. Conservation strategies should recognize Indigenous women as knowledge holders, educators, resource managers, and decision-making partners. Effective approaches should support community authority over knowledge, equitable participation, gender-responsive governance, fair recognition of contributions, and opportunities for intergenerational learning.

A sustainable approach to biodiversity conservation should ultimately integrate ecological protection with cultural continuity, Indigenous rights, gender equity, and community-led knowledge systems. Supporting Indigenous women's ability to preserve, practice, and transmit ecological knowledge can strengthen both biological diversity and the knowledge systems necessary for its long-term conservation.

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One Health Approach: Combining Indigenous Zoonotic Knowledge and AI for Public Health Surveillance

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Abstract: Zoonotic diseases continue to pose major challenges to public health because their emergence and transmission are influenced by interconnected processes involving humans, animals, and the environment. Conventional surveillance systems frequently depend on formal health infrastructure and may have limited capacity to detect early ecological and community-level changes, particularly in remote and underserved settings. Indigenous communities possess extensive place-based knowledge of animal behaviour, environmental change, wildlife health, livestock diseases, seasonal patterns, and ecological disturbances that may provide valuable signals relevant to zoonotic disease surveillance. At the same time, artificial intelligence (AI) and related computational approaches can process large and heterogeneous datasets generated from epidemiological, environmental, climatic, veterinary, and ecological sources. Integrating Indigenous zoonotic knowledge with AI within a One Health framework therefore presents an opportunity to develop surveillance systems that are locally informed, technologically advanced, and responsive to emerging health threats. Such integration should not treat Indigenous knowledge simply as another dataset but should recognize communities as knowledge holders and active participants in surveillance and decision-making. Ethical data governance, Indigenous data sovereignty, informed participation, privacy, equitable benefit sharing, cultural protocols, and transparency in AI systems are essential for responsible implementation. This review examines the conceptual basis for integrating Indigenous zoonotic knowledge with AI-enabled surveillance, discusses potential applications across human, animal, and environmental health, and identifies methodological, ethical, technological, and institutional challenges. A community-centred framework is proposed in which Indigenous knowledge and scientific technologies operate as complementary systems to strengthen early warning, risk assessment, outbreak preparedness, and sustainable public health action.
Keywords: One Health; Indigenous knowledge; zoonotic diseases; artificial intelligence; public health surveillance

1. Introduction

Zoonotic diseases represent a complex and continually evolving public health challenge because pathogen emergence is shaped by interactions among humans, animals, ecosystems, climate, land use, socioeconomic conditions, and patterns of human mobility. The risk of disease emergence is influenced by ecological disruption, changes in host populations, human–animal contact, environmental transformation, and other interconnected drivers (Taylor et al., 2001; Karesh et al., 2012; Horby et al., 2014). Global environmental change has further increased concern because climate change, biodiversity loss, habitat modification, urbanization, and changing species distributions can alter pathogen transmission dynamics and create new opportunities for spillover (Baker et al., 2022; Nova et al., 2022; Mahon et al., 2024).

The COVID-19 pandemic demonstrated the consequences of delayed recognition and response to emerging infectious disease threats. Beyond direct morbidity and mortality, pandemics can produce substantial economic and social disruption, demonstrating that infectious disease preparedness is closely connected with broader development and economic resilience (Naseer et al., 2022). The continuing emergence or re-emergence of infectious diseases, including mpox, highly pathogenic avian influenza, dengue, measles, and tuberculosis, further emphasizes the need for surveillance systems capable of

identifying changing risks across multiple sectors (Adepoju, 2024; Durrheim et al., 2021; Gulumbe et al., 2025; Krammer et al., 2025; Wu et al., 2022).

The One Health approach provides an important conceptual framework for addressing these interconnected threats. It recognizes that human health is closely linked with animal health, plant health, ecosystems, and the wider environment and therefore emphasizes coordinated, multisectoral action (World Health Organization, 2017; Sinclair, 2019). The One Health High-Level Expert Panel further developed the concept by emphasizing an integrated and unifying approach aimed at sustainably balancing and optimizing the health of people, animals, and ecosystems (One Health High-Level Expert Panel [OHHLEP] et al., 2022). One Health has consequently become increasingly important for global health security, pandemic prevention, sustainable development, and management of emerging and re-emerging infectious diseases (Gronvall et al., 2014; Mackenzie & Jeggo, 2019; Mumford et al., 2022; Riley, 2021). However, effective One Health surveillance requires information from diverse geographical, ecological, cultural, and institutional settings. Formal surveillance systems may have limited reach in remote communities where health infrastructure, diagnostic laboratories, veterinary services, and digital connectivity are constrained. Rugged terrain and geographical isolation can further complicate the implementation of integrated surveillance systems (Cao et al., 2025). These limitations create a need for complementary sources of information capable of identifying changes in animal populations, environmental conditions, and disease patterns at the community level.

Indigenous communities possess extensive knowledge developed through long-term interactions with local ecosystems. Such knowledge may include observations concerning wildlife behaviour, animal illness, livestock health, unusual mortality events, vector abundance, seasonal changes, water conditions, vegetation, and other ecological indicators. When appropriately documented and governed by communities themselves, these observations may contribute to broader One Health surveillance.

At the same time, rapid advances in artificial intelligence (AI), machine learning, big data analytics, and predictive modelling have created new possibilities for infectious disease surveillance. AI can analyse large and complex datasets, identify patterns that may not be readily apparent through conventional analysis, and support early-warning systems for emerging outbreaks (Isiaka et al., 2024; Judijanto et al., 2024; Kraemer et al., 2025). Recent work has also highlighted the potential of AI to contribute to One Health surveillance and prediction of pathogen spillover (Koopmans et al., 2025).

The integration of Indigenous zoonotic knowledge with AI therefore represents a potentially important extension of One Health surveillance. However, this integration must be designed as a partnership between knowledge systems rather than as a process through which Indigenous knowledge is simply extracted, digitized, and processed by algorithms. The present review examines the potential, challenges, ethical considerations, and future directions of combining Indigenous zoonotic knowledge and AI for public health surveillance.

2. One Health and Zoonotic Disease Surveillance

2.1 Conceptual foundations of One Health

The One Health approach recognizes that disease emergence cannot always be understood through human health systems alone. Pathogens circulate through interconnected ecological systems involving wildlife, domestic animals, livestock, vectors, humans, and environmental reservoirs. Consequently, disease prevention requires collaboration across medical, veterinary, ecological, environmental, agricultural, and public health disciplines (World Health Organization, 2017; OHHLEP et al., 2022).

One Health has also been linked to global health security and the Sustainable Development Goals because infectious disease threats can affect health, food security, livelihoods, economic stability, and environmental sustainability simultaneously (Sinclair, 2019; Mumford et al., 2022). The approach is

particularly relevant to zoonotic diseases because many emerging pathogens originate in animals and subsequently cross species barriers under favourable ecological and social conditions (Karesh et al., 2012).

2.2 Drivers of zoonotic disease emergence

Zoonotic emergence is influenced by multiple interacting factors. Human population expansion, agricultural intensification, wildlife trade, habitat modification, deforestation, biodiversity change, climate variability, and increased human–animal contact can modify pathogen transmission opportunities (Taylor et al., 2001; Horby et al., 2014).

Habitat loss is particularly important because ecological disruption may modify host distributions and increase contact among wildlife, livestock, and humans. Economic and environmental changes can consequently alter the probability and consequences of infectious disease outbreaks (Barbier, 2021). Global change can also influence pathogen and vector distributions, disease seasonality, and host susceptibility (Baker et al., 2022; Nova et al., 2022; Mahon et al., 2024).

Climate change represents another important driver. Changes in temperature, rainfall, humidity, extreme weather events, and ecological distributions can affect pathogen transmission and vector ecology. Effective surveillance under such circumstances therefore requires integration of epidemiological information with environmental and climatic observations (Wang et al., 2023).

2.3 Surveillance beyond conventional health systems

Traditional surveillance frequently relies on clinical reporting, laboratory confirmation, veterinary reporting, and government health records. Although these systems are essential, they may fail to detect early ecological changes or disease events occurring outside formal healthcare systems.

The experience of infectious disease surveillance demonstrates the importance of interdisciplinary systems that combine human, animal, and environmental information. Integrated approaches have been proposed to improve early warning and preparedness for emerging zoonotic diseases (Kelly et al., 2020; McClymont et al., 2022; Sikkema & Koopmans, 2025).

A broader surveillance strategy can therefore incorporate community observations, wildlife monitoring, veterinary data, environmental measurements, climate information, remote sensing, and epidemiological records. Indigenous knowledge can potentially contribute to this broader information architecture by providing locally contextualized observations that may not be captured by conventional surveillance networks.

3. Indigenous Zoonotic Knowledge

3.1 Nature of Indigenous ecological knowledge

Indigenous knowledge develops through long-term observation, experience, cultural transmission, and interaction with local ecosystems. Knowledge concerning animals and environmental change may be embedded within agricultural practices, hunting and pastoral traditions, food systems, medicinal practices, seasonal calendars, oral traditions, and community institutions.

In the context of zoonotic disease surveillance, relevant knowledge may include recognition of unusual animal behaviour, changes in wildlife abundance, abnormal mortality, changes in livestock health, altered vector activity, unusual environmental conditions, and changes in the timing of seasonal ecological events. Such observations are particularly valuable because they are often geographically specific. A community may recognize deviations from normal ecological patterns long before these changes are recorded by external monitoring systems.

3.2 Indigenous observations as early-warning signals

Early detection is a central objective of outbreak preparedness. Community members who interact regularly with animals and ecosystems may recognize subtle changes that precede clinically apparent outbreaks. Farmers, pastoralists, hunters, fishers, forest-dependent communities, and other local observers

can potentially contribute observations concerning animal morbidity, mortality, unusual migration, reproductive changes, vector abundance, and environmental disturbances.

This approach is consistent with the broader One Health emphasis on integrating information from multiple sectors. Emerging disease risks are shaped by environmental and animal factors as well as human health outcomes (Karesh et al., 2012; Kelly et al., 2020). Therefore, community-level observations can potentially complement laboratory-based surveillance rather than replace it.

3.3 Local ecological context

A major advantage of Indigenous observations is their contextual nature. An isolated observation of unusual wildlife mortality may have limited meaning without knowledge of local ecological conditions. Indigenous communities may possess historical knowledge that allows them to distinguish ordinary seasonal variation from unusual events.

This contextual information could be especially valuable in areas affected by climate variability, habitat change, or difficult terrain. Geographic barriers and limited infrastructure can make conventional surveillance challenging, while community-based observations may provide information from locations that are otherwise poorly monitored (Cao et al., 2025).

4. Artificial Intelligence in Public Health Surveillance

4.1 Machine learning and disease detection

AI encompasses computational approaches capable of identifying patterns, classifying observations, making predictions, and supporting decision-making. Machine learning can process large datasets derived from clinical records, laboratory surveillance, animal health systems, environmental sensors, satellite imagery, climate observations, and other sources.

The growing availability of large datasets has increased the potential for computational prediction of infectious disease dynamics (Judijanto et al., 2024). AI has also been proposed for earlier identification and management of infectious disease outbreaks by integrating diverse indicators and detecting complex relationships among variables (Isiaka et al., 2024).

4.2 AI and infectious disease modelling

Epidemic modelling traditionally uses mathematical and statistical approaches to describe disease transmission. AI can complement these methods by analysing high-dimensional datasets and identifying nonlinear relationships. Recent advances have demonstrated increasing interest in AI-based modelling of infectious disease epidemics (Kraemer et al., 2025).

In a One Health setting, models may integrate human epidemiological data with animal populations, environmental variables, climate conditions, land-use patterns, pathogen genomic information, and wildlife observations. Such integration can potentially improve risk stratification and early-warning capabilities.

4.3 AI-enabled One Health surveillance

AI has growing relevance to One Health because pathogen emergence occurs across ecological boundaries. The potential use of AI for predicting pathogen spillover illustrates how computational methods can contribute to surveillance at the human–animal–environment interface (Koopmans et al., 2025).

A holistic surveillance architecture can combine environmental, animal, and human determinants rather than analysing them separately (Singh et al., 2024). This provides a conceptual basis for incorporating community-generated observations into broader AI-supported surveillance systems.

5. Integrating Indigenous Knowledge With AI

5.1 Complementary knowledge systems

The integration of Indigenous knowledge and AI should be understood as a complementary process. Indigenous knowledge provides contextual, experiential, and place-based information, whereas AI provides computational capacity for processing large quantities of heterogeneous information.

Neither system is sufficient independently for comprehensive surveillance. Community observations may be rich in ecological meaning but geographically limited, while large-scale computational systems may identify statistical patterns without understanding their cultural or ecological context.

The goal should therefore be to establish a two-way knowledge system in which community observations inform scientific surveillance while analytical outputs are returned to communities in meaningful and usable forms.

5.2 Community-generated surveillance data

Community members could contribute structured observations through mobile applications, community health platforms, participatory mapping systems, voice-based reporting, or other appropriate technologies. Possible indicators could include:

- unusual animal mortality;
- changes in wildlife behaviour;
- sudden livestock illness;
- unusual vector abundance;
- changes in water quality or availability;
- unusual seasonal ecological events;
- changes in animal migration;
- suspected disease clusters; and
- environmental disturbances.

These observations could subsequently be integrated with epidemiological, veterinary, environmental, and climatic datasets.

5.3 AI-assisted interpretation

AI systems could classify incoming observations, identify unusual spatial or temporal patterns, estimate risk, and prioritize events for further investigation. For example, repeated community reports of unusual livestock illness combined with abnormal temperature and precipitation patterns could trigger enhanced veterinary surveillance.

However, automated predictions should not be interpreted as definitive diagnoses. AI outputs should instead support expert and community decision-making. Laboratory confirmation and field investigation remain essential for establishing pathogen identity and transmission pathways.

6. A Community-Centred One Health Surveillance Framework

A community-centred framework can be conceptualized as a six-stage process.

Stage 1: Community engagement

Surveillance should begin with meaningful engagement with communities. Community members should participate in defining surveillance objectives, determining what information can be shared, identifying culturally appropriate communication mechanisms, and establishing decision-making structures.

Stage 2: Knowledge identification

Relevant Indigenous observations should be identified through participatory methods. Knowledge should not automatically be treated as public information. Some knowledge may be culturally restricted, sacred, confidential, or collectively owned.

Stage 3: Ethical data governance

Data governance mechanisms should specify who owns information, who can access it, how it can be used, and what benefits communities receive. These principles are particularly important because AI systems may permit information to be reused for purposes beyond the original surveillance objective.

Stage 4: Multimodal data integration

Community observations can be combined with epidemiological, veterinary, environmental, climatic, geospatial, and laboratory datasets. Integrated surveillance models are increasingly emphasized as important components of emerging infectious disease preparedness (McClymont et al., 2022; Singh et al., 2024).

Stage 5: AI-assisted analysis

Machine learning and other computational approaches can identify patterns and generate risk estimates. Big data approaches may help identify relationships among multiple disease determinants (Judijanto et al., 2024), while AI-based epidemic modelling can support prediction and scenario analysis (Kraemer et al., 2025).

Stage 6: Community feedback and response

Surveillance should conclude with communication and action rather than simply data extraction. AI-generated alerts and risk assessments should be communicated to relevant communities, health authorities, veterinary services, and environmental agencies. Community feedback should also be incorporated into subsequent surveillance cycles.

7. Data Sovereignty, Ethics, and Indigenous Rights

7.1 Indigenous data sovereignty

Indigenous knowledge should not be treated as freely available raw material for technological development. Community authority over knowledge and information must be respected throughout the surveillance process.

Data governance should address ownership, access, storage, secondary use, publication, commercialization, and benefit sharing. These considerations are particularly important for AI because models can reproduce, transform, and potentially redistribute information at large scales.

7.2 Free, prior, and informed participation

Participation should be based on meaningful understanding of the objectives, risks, benefits, and possible future uses of the surveillance system. Communities should have opportunities to negotiate how their knowledge is represented and used.

7.3 Privacy and confidentiality

Community surveillance may generate information about households, animal holdings, health events, geographic locations, or culturally sensitive practices. Appropriate safeguards are therefore necessary to minimize privacy risks.

7.4 Avoiding knowledge appropriation

Digital transformation can create risks of knowledge appropriation if external researchers or institutions collect Indigenous observations without adequate recognition, control, or benefit sharing. The objective should be collaborative knowledge production rather than extraction.

8. Algorithmic Bias and Responsible AI

AI systems can reproduce biases present in training data. If community observations are systematically underrepresented, poorly labelled, or interpreted using inappropriate assumptions, models may produce unreliable predictions.

Explainable AI can improve transparency by providing information about the variables or patterns influencing model predictions. Explainability has become an important component of responsible AI

because complex models may otherwise operate as opaque systems (Barredo Arrieta et al., 2020; Minh et al., 2022).

Methods such as SHAP-based interpretation provide approaches for estimating the contribution of individual features to model predictions (Lundberg & Lee, 2017). Similarly, model-agnostic approaches such as LIME can help explain individual predictions (Ribeiro et al., 2016).

For community-centred One Health surveillance, interpretability is particularly important. Communities and health professionals should be able to understand why an alert has been generated and what evidence supports it. AI should therefore function as an assistive analytical tool rather than an unquestionable decision-maker.

9. Digital Technologies and Community Participation

Digital technologies can expand the geographical reach of surveillance but may simultaneously create new inequalities. Remote communities may experience limited internet connectivity, electricity shortages, lack of digital devices, or insufficient technical training.

Technological implementation should therefore prioritize accessible platforms. Depending on local circumstances, surveillance may use smartphone applications, SMS-based systems, offline data collection, voice reporting, community health workers, or hybrid paper–digital systems.

Technological solutions should be adapted to local conditions rather than imposing standardized platforms. This is particularly important in geographically difficult environments where conventional infrastructure is limited (Cao et al., 2025).

10. Applications Across the One Health Continuum

10.1 Wildlife health

Wildlife can serve as an important reservoir or host for zoonotic pathogens. Community members with extensive ecological knowledge may recognize changes in wildlife abundance, behaviour, movement, or mortality.

These observations could be integrated with wildlife surveillance, environmental monitoring, and AI-based risk modelling to identify unusual ecological patterns.

10.2 Livestock health

Livestock often occupy an important position at the human–animal interface. Farmers and pastoralists may detect changes in animal behaviour, productivity, morbidity, or mortality before formal veterinary systems receive reports.

Integrated veterinary and community surveillance could improve early recognition of diseases with zoonotic potential. The One Health approach is particularly relevant for diseases in which animal health events precede human cases.

10.3 Vector-borne diseases

Climate and ecological changes can alter vector distributions and disease transmission. Environmental surveillance combined with community observations could provide additional information regarding changes in vector abundance or seasonal activity. Climate-driven changes in infectious disease risk reinforce the need for surveillance systems that combine epidemiological and environmental data (Wang et al., 2023).

10.4 Food safety and food systems

Indigenous and local communities often possess detailed knowledge concerning food preparation, animal husbandry, water sources, and seasonal food availability. Such information can potentially contribute to monitoring foodborne and zoonotic hazards.

Food systems are also important because infectious disease risks can affect livelihoods and economic security. The broader economic consequences of infectious disease outbreaks demonstrated during COVID-19 reinforce the need for integrated preparedness strategies (Naseer et al., 2022).

10.5 Environmental change

Environmental disruption can increase infectious disease risks by altering host distributions and ecological relationships. Habitat loss, for example, can influence disease emergence by modifying ecological interactions (Barbier, 2021).

Community observations can provide geographically detailed information concerning deforestation, water changes, unusual wildlife activity, land-use transformation, or other environmental disturbances. These observations may subsequently be incorporated into AI-enabled environmental risk models.

11. Emerging Disease Examples and the Need for Integrated Surveillance

The continued appearance of emerging and re-emerging diseases illustrates the importance of surveillance systems that extend across sectors.

Tuberculosis resurgence and persistent weaknesses in disease-control systems demonstrate the consequences of insufficient surveillance and health-system preparedness (Gulumbe et al., 2025). Cholera outbreaks similarly exhibit strong spatial and temporal relationships with environmental and social conditions, highlighting the importance of geographically informed surveillance (Moore et al., 2024).

The emergence of mpox as a public health emergency demonstrated how previously under-recognized transmission patterns can rapidly acquire international significance (Adepoju, 2024). Measles resurgence also illustrates the consequences of disruptions to routine public health systems and vaccination programmes (Durrheim et al., 2021).

Highly pathogenic avian influenza H5N1 provides a particularly relevant One Health example because viral evolution and circulation in animal populations have implications for human health (Krammer et al., 2025). Dengue likewise demonstrates the importance of understanding interactions among vectors, climate, human populations, and environmental conditions (Wu et al., 2022).

More broadly, emerging and re-emerging fatal viral diseases demonstrate that infectious disease threats remain dynamic and that preparedness must extend beyond individual pathogens (Choi, 2021). The continuing burden of infectious disease therefore supports investment in surveillance systems capable of identifying threats before they become widespread (Bloom & Cadarette, 2019).

12. Challenges to Implementation

Several challenges may limit the practical integration of Indigenous knowledge and AI.

12.1 Knowledge heterogeneity

Indigenous knowledge is diverse and context-specific. A surveillance framework developed in one community may not be directly applicable elsewhere.

12.2 Data standardization

Community observations may not initially follow standardized terminology or measurement protocols. Excessive standardization, however, may remove important contextual information. A balance between structured data collection and preservation of local meaning is therefore required.

12.3 Digital inequity

Limited connectivity, hardware availability, electricity, and digital literacy can prevent equitable participation.

12.4 Algorithmic bias

AI systems trained primarily on formal datasets may perform poorly when applied to communities with different ecological, demographic, or epidemiological characteristics. Responsible AI principles and continuous model evaluation are therefore essential (Barredo Arrieta et al., 2020; Minh et al., 2022).

12.5 Institutional fragmentation

One Health surveillance often involves separate governmental and institutional structures. Human health, veterinary, wildlife, agricultural, and environmental agencies may have different mandates and data systems. Effective implementation therefore requires mechanisms for information sharing and coordinated response (Gronvall et al., 2014; Mumford et al., 2022).

12.6 Trust and historical inequities

Communities may be reluctant to participate in externally controlled research if previous experiences have involved knowledge extraction or inadequate benefit sharing. Building long-term relationships is therefore more important than short-term data collection.

12.7 Scientific validation

Indigenous observations should be respected while also being evaluated through appropriate epidemiological and scientific methods when they are used for public health decision-making. AI-generated predictions similarly require independent validation and field investigation.

13. Opportunities for Sustainable Integration

Despite these challenges, the integration of Indigenous knowledge and AI offers several opportunities.

First, community-based surveillance can extend the geographical reach of formal systems. Second, AI can assist in analysing large quantities of heterogeneous information that would be difficult to process manually. Third, integrated One Health platforms can connect human, veterinary, wildlife, environmental, and climatic information.

International experience with One Health surveillance demonstrates the value of interdisciplinary approaches for identifying and responding to emerging zoonotic threats (Kelly et al., 2020). Pandemic preparedness increasingly requires surveillance systems capable of detecting viral emergence across ecological interfaces (Sikkema & Koopmans, 2025).

The development of AI-enabled One Health systems may therefore strengthen early warning if technological innovation is accompanied by appropriate governance. AI should not replace community knowledge or conventional epidemiological expertise. Instead, it should increase the analytical capacity available to communities, researchers, and public health authorities.

14. Discussion

The integration of Indigenous zoonotic knowledge with AI represents an opportunity to expand the conceptual and operational boundaries of One Health surveillance. Conventional surveillance systems are essential but may not adequately capture early ecological changes occurring at local scales. Indigenous communities can provide detailed observations generated through long-term interaction with animals and ecosystems, while AI can provide the computational capacity required to analyse these observations alongside large-scale environmental, epidemiological, veterinary, and climatic datasets.

The scientific rationale for this integration is strengthened by evidence that disease emergence is driven by interacting ecological, climatic, environmental, and socioeconomic processes (Taylor et al., 2001; Karesh et al., 2012; Baker et al., 2022; Mahon et al., 2024). Habitat loss and other environmental changes can modify disease risk (Barbier, 2021), while climate change can alter the spatial and temporal dynamics of infectious diseases (Wang et al., 2023). A surveillance system restricted to clinical human cases may therefore identify disease only after important ecological changes have already occurred.

The One Health framework offers an appropriate foundation because it explicitly emphasizes collaboration among human, animal, and environmental health sectors (World Health Organization, 2017; OHHLEP et al., 2022). Existing One Health surveillance approaches have demonstrated the importance of integrating environmental and animal determinants with human health information (Singh et al., 2024).

The inclusion of Indigenous observations could further strengthen this architecture by providing information generated at the community–ecosystem interface.

AI may provide additional analytical advantages. Big data approaches can identify patterns across large datasets (Judijanto et al., 2024), while AI-based outbreak modelling can support disease forecasting (Kraemer et al., 2025). AI has also been specifically identified as a potential tool for One Health spillover prediction (Koopmans et al., 2025). Nevertheless, prediction without contextual understanding can lead to false alarms or inappropriate interventions. Indigenous knowledge can contribute contextual interpretation, while scientific surveillance can provide validation.

The ethical dimension is equally important. Indigenous knowledge cannot simply be converted into machine-readable data without considering ownership, cultural protocols, privacy, consent, and benefit sharing. A technologically sophisticated surveillance system that disregards community rights would not represent a genuinely sustainable One Health approach.

Responsible AI is therefore necessary. Explainable AI can make computational predictions more interpretable (Barredo Arrieta et al., 2020; Minh et al., 2022), while methods such as SHAP and LIME can provide additional insight into individual model predictions (Lundberg & Lee, 2017; Ribeiro et al., 2016). Such transparency is particularly important where surveillance outputs may influence resource allocation, outbreak declarations, animal-control measures, or other consequential decisions.

Recent infectious disease events demonstrate the practical importance of such integrated systems. COVID-19 generated profound global health and economic consequences (Naseer et al., 2022), while mpox, measles, H5N1, dengue, tuberculosis, cholera, and other diseases continue to demonstrate the dynamic nature of infectious disease risks (Adepoju, 2024; Durrheim et al., 2021; Gulumbe et al., 2025; Krammer et al., 2025; Moore et al., 2024; Wu et al., 2022). These examples suggest that future surveillance must be flexible enough to identify both known threats and unexpected changes.

The central principle emerging from this review is therefore that AI and Indigenous knowledge should be treated as complementary rather than competing systems. Indigenous knowledge provides ecological memory, local context, and community-level observations, while AI provides computational scalability, pattern recognition, and predictive capability. Formal epidemiology, laboratory science, veterinary medicine, environmental science, and community knowledge can together produce a more comprehensive surveillance architecture.

15. Future Research Directions

Future research should focus on developing practical frameworks for collecting and integrating community observations while maintaining Indigenous control over knowledge and data.

Longitudinal studies should evaluate whether Indigenous observations can reliably predict measurable changes in animal health, vector abundance, environmental conditions, or zoonotic disease incidence. Such studies should be designed collaboratively with participating communities.

AI research should investigate methods for incorporating qualitative and semi-structured community observations alongside quantitative epidemiological and environmental data. Multimodal AI may eventually allow textual, visual, spatial, climatic, veterinary, and epidemiological information to be analysed jointly.

Future work should also examine model fairness across different geographical and cultural contexts. Explainability and participatory model evaluation should become standard components of AI-enabled One Health surveillance.

Finally, policy research is needed to establish governance frameworks addressing data ownership, community consent, intellectual property, privacy, benefit sharing, cross-sector data exchange, and accountability. The development of effective One Health surveillance requires not only technological innovation but also institutional coordination and long-term community partnerships.

16. Conclusion

Integrating Indigenous zoonotic knowledge with artificial intelligence provides a promising opportunity to strengthen One Health surveillance and public health preparedness. Indigenous communities contribute detailed, place-based knowledge of animals, ecosystems, environmental changes, and disease-related observations, while AI can support large-scale data integration, pattern recognition, risk assessment, and early-warning functions.

The value of this approach depends on maintaining a genuine partnership among communities, scientists, healthcare professionals, veterinarians, environmental agencies, and technology developers. Indigenous knowledge should not be reduced to an extractable dataset, and AI should not replace human or community judgement. Instead, both should operate within an ethical and participatory framework that respects Indigenous rights, protects sensitive information, promotes transparency, and ensures equitable benefits.

A community-centred One Health surveillance model combining local ecological knowledge, scientific observation, and responsible AI could contribute to earlier recognition of zoonotic threats, stronger outbreak preparedness, and more context-sensitive public health responses. The future of integrated surveillance should therefore focus not simply on collecting more data, but on creating trustworthy systems in which different forms of knowledge are recognized, protected, validated, and translated into effective action.

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Indigenous Games as Cultural Heritage, Youth Empowerment, Health, Peace, and Community Sustainability

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Abstract: Indigenous games represent more than recreational activities; they are living expressions of cultural identity, traditional knowledge, physical activity, social relationships, and community values. This review examines the contemporary significance of Indigenous and traditional games as instruments for cultural preservation, youth empowerment, health promotion, social inclusion, peacebuilding, and sustainable community development. Indigenous games can transmit knowledge between generations while creating opportunities for physical activity and collective participation. Their community-centered character may also support social cohesion and intercultural dialogue. However, globalization, commercialization, migration, inadequate documentation, and declining transmission between generations threaten many traditional practices. Sustainable safeguarding therefore requires community leadership, ethical documentation, youth participation, culturally appropriate education, research partnerships, and responsible international sporting platforms. The World Council of Indigenous Games provides an important framework for international cooperation and knowledge exchange. Integrating Indigenous games into culturally respectful sport, education, health, and development programs may strengthen cultural continuity while generating broader social and community benefits.

Keywords: Indigenous Games; traditional sports; cultural heritage; youth empowerment; physical activity; community health; peacebuilding; sustainability; Indigenous knowledge; social inclusion

1. Introduction

Indigenous and traditional games are important expressions of the histories, values, knowledge systems, and identities of communities. Unlike many modern sports that are primarily organized around standardized international rules, Indigenous games frequently emerge from local environments, customary practices, ceremonies, livelihood activities, social relationships, and intergenerational teaching.

The World Council of Indigenous Games (WIG) identifies the promotion and development of Indigenous Games as its central mission and emphasizes Olympic values, young people, excellence, respect, friendship, and international cooperation. The organization reports activities involving more than 100 countries and territories and identifies knowledge sharing, partnerships, sport development, and Indigenous cultural preservation as important areas of work.

Traditional sports and games have also been recognized internationally as components of intangible cultural heritage. They can provide opportunities for peaceful coexistence, social interaction, intercommunity dialogue, and transmission of cultural knowledge (UNESCO, 2015).

The significance of Indigenous Games therefore extends beyond athletic performance. They can function simultaneously as cultural practices, educational tools, recreational activities, community events, and mechanisms for strengthening social identity.

2. Indigenous Games as Living Cultural Heritage

Cultural heritage is not restricted to physical monuments, artifacts, or historical documents. Intangible heritage includes practices, knowledge, skills, rituals, celebrations, and forms of community expression transmitted between generations.

Indigenous games are particularly important because they preserve knowledge through participation. Children and young people may learn traditional rules, techniques, stories, values, ecological knowledge, and social responsibilities by observing and participating with older community members.

UNESCO's documentation of Indigenous Games emphasizes their relationship with rituals, celebrations, community relationships, cultural identity, and interethnic dialogue (UNESCO, 2015).

This participatory character differentiates traditional games from heritage that is preserved only in museums or written archives.

The loss of Indigenous games can therefore represent more than the loss of recreational activities. It can indicate disruption of intergenerational cultural transmission.

Table 1. Major cultural and social functions of Indigenous Games

Function	Principal mechanism	Potential community outcome
Cultural preservation	Transmission of traditional practices	Strengthened cultural identity
Intergenerational learning	Participation of elders and youth	Knowledge continuity
Youth engagement	Structured recreational participation	Leadership and social participation
Social cohesion	Collective activity	Stronger community relationships
Intercultural dialogue	Interaction among communities	Greater mutual understanding
Peacebuilding	Cooperative and ceremonial participation	Reduced social barriers
Physical activity	Movement and sport participation	Improved active lifestyles
Environmental knowledge	Games linked with local landscapes	Greater ecological awareness

3. Historical Dimensions of Indigenous Sport

Sport has not always had a uniformly positive relationship with Indigenous communities. In several colonial contexts, organized sport was associated with assimilation and the replacement of Indigenous cultural practices.

Forsyth and Wamsley (2006) demonstrated that sport could function as a contested cultural space: it could be used for assimilation, but Indigenous communities could also reclaim sport as a mechanism for cultural resistance and self-determination.

This historical perspective is essential when developing contemporary Indigenous sporting programs.

Indigenous Games should not simply be converted into standardized competitive sports for external audiences. Their cultural meanings, community ownership, traditional rules, ceremonial dimensions, and Indigenous intellectual and cultural rights should be respected.

Contemporary international Indigenous sporting organizations can therefore play an important role in changing the relationship between sport and cultural identity—from assimilation toward empowerment.

4. Indigenous Games and Youth Empowerment

Young people are central to the sustainability of traditional games.

A traditional practice cannot survive indefinitely if knowledge remains restricted to older generations. Youth participation provides a pathway through which cultural knowledge can continue.
Indigenous Games may offer young people opportunities to develop physical skills, teamwork, discipline, leadership, communication, confidence, and cultural awareness.
The WIG explicitly identifies young people as a focus of its mission. Its membership and program structure also emphasize sport science, physical education, traditional games, research, and athlete development.
Youth-oriented programs should nevertheless avoid treating Indigenous youth simply as athletes. Young participants can also serve as cultural researchers, coaches, event organizers, storytellers, digital archivists, and community ambassadors.
This broader model of participation may provide more sustainable outcomes.

5. Physical Activity and Community Health

Regular physical activity is widely recognized as an important component of healthy living.
Indigenous Games can provide culturally relevant opportunities for physical activity because they are embedded in familiar community environments and social practices.
Traditional activities may include running, wrestling, archery, canoeing, throwing, dancing, jumping, team games, and other forms of movement.
Participation may therefore support physical fitness while simultaneously strengthening cultural identity.
The health potential of Indigenous Games should not, however, be assumed automatically. Program evaluation should assess participation rates, injury patterns, accessibility, gender participation, age groups, physical activity intensity, and longer-term health outcomes.

Table 2. Potential health and development contributions of Indigenous Games

Domain	Potential contribution	Suggested indicator
Physical health	Increased physical activity	Activity duration and frequency
Cardiovascular fitness	Running and endurance activities	Fitness assessment
Musculoskeletal health	Strength and movement	Functional performance
Mental well-being	Social connection and identity	Validated well-being scales
Youth development	Leadership and teamwork	Participation and leadership measures
Social health	Community interaction	Social connectedness measures
Cultural health	Identity and belonging	Cultural participation measures
Community development	Local events and partnerships	Program continuity and participation

6. Indigenous Games and Mental Well-Being

Mental well-being is influenced by social relationships, cultural identity, participation, physical activity, and a sense of belonging.
Indigenous Games can potentially contribute to these dimensions by creating opportunities for community participation and cultural expression.
A culturally meaningful sporting environment may provide a stronger sense of belonging than activities disconnected from local identity.
However, research should avoid making simplistic claims that traditional games independently prevent mental illness. Mental health outcomes are multidimensional and require consideration of socioeconomic conditions, access to healthcare, discrimination, education, family relationships, and other determinants.
Community-led research can help identify which aspects of Indigenous Games are most relevant to well-being.

7. Indigenous Games and Peacebuilding

Traditional games can create social spaces in which people interact beyond political, geographic, linguistic, or ethnic divisions.

UNESCO describes traditional games as instruments that can support peaceful coexistence, healthy community relationships, integration, reciprocity, and interethnic dialogue.

These characteristics make Indigenous Games relevant to peacebuilding.

Competitive sport can create rivalry, but Indigenous Games may also emphasize cooperation, ceremony, hospitality, cultural exchange, and collective celebration.

The distinction between competition and cooperation is therefore important.

A sustainable Indigenous Games program should not measure success exclusively through medals or rankings. Cultural exchange, participation, respect, friendship, and community relationships may be equally important outcomes.

8. Intercultural Dialogue

International Indigenous sporting events bring communities with different languages, histories, and cultural practices into shared spaces.

Such encounters can increase understanding when they are based on mutual respect rather than cultural appropriation.

The World Indigenous Games has historically been described as a setting for celebrating Indigenous diversity and creating opportunities for different peoples to exchange cultural values.

International events can therefore function as cultural diplomacy at the community level.

Nevertheless, intercultural dialogue requires careful organization. Communities should control how their traditions are presented, documented, photographed, commercialized, or reproduced.

9. Traditional Knowledge and Indigenous Intellectual Rights

Indigenous games can contain traditional knowledge relating to materials, ecological environments, body techniques, stories, symbols, ceremonies, and customary rules.

Documentation of these practices can help prevent loss, but documentation itself creates ethical challenges.

External researchers should not assume that traditional knowledge is automatically available for unrestricted publication or commercialization.

The protection of Indigenous cultural expressions is therefore an essential component of responsible research.

10. Environmental Knowledge and Sustainability

Many Indigenous Games developed in close relationship with local environments.

Water sports, traditional hunting-related games, running activities, climbing, throwing, and other practices may reflect knowledge of landscapes and natural resources.

This creates an opportunity to connect sport with environmental education.

The World Council of Indigenous Games has increasingly emphasized relationships between Indigenous knowledge, sustainable land use, youth engagement, and environmental awareness.

Traditional games may therefore provide culturally relevant mechanisms for communicating environmental values.

However, sustainability should not be romanticized. Indigenous communities themselves experience environmental degradation, climate change, land loss, displacement, and resource pressures.

Sport programs should therefore be connected to practical community development rather than treated as substitutes for environmental policy.

11. Globalization and Threats to Traditional Games

Globalization has expanded access to modern sports but can simultaneously threaten local games.
Young people may increasingly encounter standardized sports through schools, television, social media, and international competitions. Traditional games may subsequently be perceived as outdated or less prestigious. Safeguarding therefore requires more than holding occasional festivals. Sustainable programs should operate throughout the year and connect community events with education, research, coaching, documentation, and youth development.

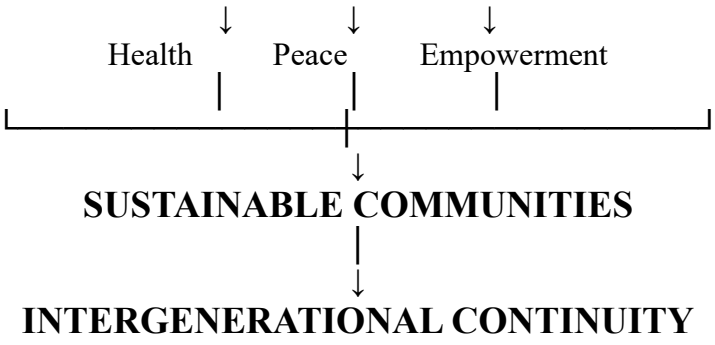
12. Role of the World Council of Indigenous Games (WIG)

The World Council of Indigenous Games provides an international platform for Indigenous and traditional games.Its stated objectives include preservation and promotion of Indigenous Games, coordination of regional activities, support for grassroots athletes and communities, implementation of policies, and development of connections between local organizations and international structures. Its regional framework includes African, Asian, European, Pan-American, and Oceanian structures.
These activities are consistent with the broader concept of sport for development and peace.

13. Research and Evidence Development

Despite increasing recognition of traditional games, the scientific literature remains uneven.
Many Indigenous sporting practices have not been systematically evaluated for physical activity characteristics, injury patterns, psychological outcomes, social benefits, or cultural effects.
Future research should use mixed-method approaches.
Quantitative studies can measure physical activity, fitness, participation, injury rates, and health outcomes.
Qualitative research can investigate identity, cultural meaning, community perceptions, intergenerational transmission, and Indigenous knowledge.
Participatory action research may be particularly appropriate because it enables communities to participate in defining research questions and interpreting findings.

Figure 1. Proposed community-centered model for sustainable Indigenous Games



14. Gender Inclusion and Participation

Inclusive Indigenous Games programs should provide appropriate opportunities for women and girls as athletes, coaches, cultural practitioners, organizers, researchers, and leaders.

Gender inclusion should be designed in consultation with communities because cultural contexts differ substantially.

Programs should assess barriers to participation, including safety, transport, family responsibilities, access to facilities, social expectations, and financial limitations.

Women should not be included solely as participants; their knowledge and leadership can be important to cultural preservation.

15. Indigenous Games and Education

Schools and universities can contribute to safeguarding traditional games.

Such programs should be developed with Indigenous communities rather than imposing external interpretations.

Educational institutions can also support systematic documentation and evaluation while respecting Indigenous data sovereignty.

16. Digital Preservation and Modern Technology

Digital technologies provide new opportunities to document and transmit traditional games.

Video archives, mobile applications, digital storytelling, geographic information systems, and online educational platforms can support intergenerational learning.

However, digital preservation also creates risks.

Once traditional knowledge is placed online, it may be copied, modified, commercialized, or used without permission.

Digital initiatives should therefore use community-controlled access systems where appropriate.

Technology should serve cultural communities rather than replace their authority over cultural knowledge.

17. Economic and Community Development

Indigenous Games can generate local economic activity through festivals, coaching, tourism, cultural events, equipment production, accommodation, transport, and community enterprises.

Economic development should nevertheless remain community-centered.

Commercialization that removes community ownership may undermine the very cultural heritage that the sporting event seeks to preserve.

Revenue-sharing models, local procurement, community enterprises, and transparent governance can help ensure that economic benefits remain within participating communities.

18. Integrating Indigenous Games with Sustainable Development

Indigenous Games can contribute to multiple development objectives.
Physical activity relates to health. Youth participation relates to education and empowerment. Cultural preservation relates to inclusive communities. Environmental knowledge relates to sustainability. Intercommunity sporting activities can support peace and social cohesion.
However, these relationships should be treated as opportunities rather than automatic outcomes.
Programs should establish measurable objectives and evaluate them systematically.

Proposed monitoring framework

Input indicators: funding, facilities, coaches, community participation, cultural advisors.

Process indicators: training sessions, youth participation, workshops, cultural events, research activities.

Output indicators: number of participants, games documented, coaches trained, communities involved.

Outcome indicators: physical activity, cultural knowledge, social connectedness, youth leadership, intercultural interaction.

Long-term indicators: continuity of traditional practices, community ownership, improved participation, sustainable financing, and intergenerational transmission.

19. Challenges for Future Development

Several challenges require attention.
First, international organizations must avoid presenting Indigenous cultures as homogeneous. Indigenous communities possess distinct languages, histories, traditions, and governance structures.
Second, competition should not replace cultural meaning.
Third, research should be conducted ethically and collaboratively.
Fourth, cultural commercialization should be carefully regulated.
Fifth, traditional games require sustainable funding rather than dependence on occasional international events.
Finally, governments, educational institutions, sporting organizations, researchers, and communities should coordinate their efforts.

20. Future Perspectives

The future of Indigenous Games depends on whether they remain living community practices rather than becoming merely cultural performances for external audiences.
Future programs should emphasize community ownership, youth leadership, cultural rights, research, physical activity, environmental stewardship, and international cooperation.
The World Council of Indigenous Games can contribute to this process by facilitating networks among Indigenous communities and supporting research and knowledge exchange.
International recognition can be valuable, but local community authority should remain central.
The most sustainable model is therefore one in which Indigenous Games are simultaneously protected as heritage, practiced as sport, transmitted through education, evaluated through research, and integrated into community development.

21. Discussion

Indigenous Games occupy an important position at the intersection of sport, culture, health, education, and sustainable development.

Their value cannot be reduced to athletic competition.

They may preserve cultural memory, provide opportunities for physical activity, strengthen youth identity, encourage intergenerational relationships, and create spaces for dialogue between communities.

Historical evidence also demonstrates that sport has been politically complex. Indigenous communities have experienced sport both as an instrument of assimilation and as a mechanism for resistance and self-determination (Forsyth & Wamsley, 2006).

This history reinforces the need for community control.

The contemporary development of Indigenous Games should therefore avoid reproducing earlier patterns in which external organizations define Indigenous cultures without meaningful Indigenous participation.

A community-centered model provides a stronger foundation.

The supplied literature on inflammation, nanotechnology, antimicrobial resistance, and renal biomarkers does not directly examine Indigenous Games, but it can be considered relevant to the broader multidisciplinary health-research framework. Shallal (2020), for example, demonstrates the importance of lifestyle-related biochemical research, while Shallal (2025a) illustrates the complexity of inflammatory and immunomodulatory pathways. Shallal et al. (2022) and Shallal and Owaid (2022) further demonstrate the need to evaluate technological interventions through both benefits and potential risks. Guma et al. (2026) illustrates the importance of molecular and antimicrobial surveillance in community health research.

These studies should not be interpreted as direct evidence for the health effects of Indigenous Games. Rather, they reinforce the broader importance of multidisciplinary, evidence-based approaches to community health.

22. Conclusion

Indigenous Games are living cultural practices with potential contributions to heritage preservation, youth empowerment, physical activity, social cohesion, peacebuilding, education, and sustainable community development. Their future depends on meaningful Indigenous leadership, intergenerational transmission, ethical research, inclusive participation, and sustainable institutional support. International platforms can strengthen cooperation and visibility, but cultural ownership must remain with Indigenous communities. Future research should combine quantitative health assessment with qualitative investigation of identity, culture, community relationships, and traditional knowledge. Properly supported, Indigenous Games can become more than sporting events: they can provide community-centered pathways connecting cultural continuity, healthy lifestyles, youth development, environmental awareness, intercultural dialogue, and peaceful coexistence.

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CHAMPION FIRST - A PEOPLE-CENTRED FRAMEWORK FOR EXCELLENCE, CONTINUOUS IMPROVEMENT AND SUSTAINABLE IMPACT

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1. Abstract: In an increasingly complex world, organizations and communities require more than conventional performance-management systems. Sustainable excellence depends on the ability to identify potential, develop capability, improve performance, recognize achievement and create leaders who can continuously improve themselves and others. The **World Council of Indigenous Games (WIG)** has developed the **Champion First** approach as a people-centred framework for excellence, capability development, continuous improvement, leadership and sustainable impact. Champion First is inspired by established improvement philosophies such as **DMAIC, PDCA, Kaizen, Total Quality Management, Lean Management and Continuous Improvement**, while introducing a distinctive emphasis on the **individual, community, culture, knowledge and long-term impact**.

The framework is built around three primary stages:

- **ASSESS :** Understand the current state, potential, capability, needs, strengths and opportunities.
- **IMPROVE:** Develop capability, remove barriers, implement improvement and create measurable progress.
- **CHAMPION:** Recognize achievement, develop leadership, share knowledge and empower the Champion to create wider impact.

The fundamental philosophy is: **"Develop the Champion first; sustainable success follows."**

Champion First can be applied across Indigenous Games, sports, education, youth development, indigenous knowledge, leadership, community development, sustainability, organizations and social-impact initiatives.

Keywords: *Champion First, World Council of Indigenous Games (WIG), Indigenous Excellence, Indigenous Knowledge, People-Centred Development, Continuous Improvement, Sustainable Development, Leadership Development, Champion Development, Community Empowerment, Capacity Building, Cultural Preservation, Indigenous Games, Indigenous Sports, Youth Development, Skills Development, Innovation, Digital Transformation, Artificial Intelligence, Green Technology, Environmental Sustainability, Social Impact, Knowledge Transfer, Mentoring, Coaching, PDCA, DMAIC, Kaizen, Lean Management, Total Quality Management, Performance Improvement, Organizational Excellence, Community Development, Knowledge Management, Cultural Heritage, Intergenerational Learning, Responsible Innovation, Leadership, Empowerment, Resilience, Global Indigenous Development.*

2. Introduction: Traditional improvement methodologies generally focus on improving a process, product, service, organization or measurable outcome.

For example:

- **PDCA** focuses on continuous cycles of planning, implementation, checking and action.
- **DMAIC** focuses on defining problems, measuring performance, analyzing causes, improving processes and controlling results.
- **Kaizen** promotes continuous incremental improvement.

These methodologies have contributed significantly to organizational excellence.

However, WIG recognizes another important dimension:

Who is responsible for creating and sustaining the improvement?

- Behind every process is a person.
- Behind every organization is a team.
- Behind every community is a group of people.

- Behind every cultural tradition is a knowledge holder.
- Behind every achievement is a Champion.

Therefore, Champion First begins with the **human being**, rather than beginning only with the process.

3. Why Champion First? Many improvement programmes answer:

"What should we improve?" Champion First additionally asks:

"Who are we developing?"

It considers five fundamental questions:

1. Where are we today?
2. What strengths and capabilities already exist?
3. What needs to improve?
4. How can improvement be sustained?
5. How can achievement create Champions who develop others?

This creates a transition from:

- **Activity → Improvement → Achievement → Leadership → Sustainable Impact**

4. The Champion First Architecture: Champion First consists of three core stages supported by seven development dimensions.

Three Core Stages

1. **ASSESS:** Establish the current state.
2. **IMPROVE:** Build capability and create measurable improvement.
3. **CHAMPION:** Recognize, empower and multiply excellence.

Seven Development Dimensions

1. Champion Mindset
2. Leadership
3. Learning
4. Performance
5. Innovation
6. Culture
7. Sustainability

Together, these create a holistic development architecture.

5. The ASSESS Stage

5.1 Purpose: Assessment is the starting point of Champion First.

Assessment does not mean searching only for weaknesses.
It identifies:

- Existing strengths
- Knowledge
- Skills
- Experience
- Potential
- Performance
- Challenges
- Opportunities
- Cultural resources
- Leadership capability
- Improvement opportunities
- Sustainability requirements

The fundamental question is: **"Where are we now?"**

5.2 Assessment Framework: WIG recommends considering multiple dimensions.

- **A – Ability:** What can the individual or organization currently do?
- **S – Strengths:** What existing strengths can be leveraged?
- **S – Skills:** What technical, professional or traditional skills exist?
- **E – Environment:** What environmental and community factors influence performance?
- **S – Sustainability:** Can the improvement continue over time?
- **S – Stakeholders:** Who benefits from the improvement?

The assessment therefore establishes a baseline for improvement.

6. The IMPROVE Stage: Once the current state has been assessed, the next stage is improvement. Improvement may involve:

- Training
- Coaching
- Mentoring
- Education
- Process redesign
- Technology
- Digital transformation
- Innovation
- Leadership development
- Cultural documentation
- Knowledge sharing
- Environmental action
- Community programmes
- Performance improvement

The key question becomes: **"How can we move from the current state to a better state?"**

7. Improvement Tools within Champion First: Champion First does not seek to replace existing quality and improvement methodologies. Instead, it can provide a **people-centred framework within which established tools can be applied**.

PDCA - PLAN → DO → CHECK → ACT : Useful for continuous improvement and iterative learning.
DMAIC - DEFINE → MEASURE → ANALYZE → IMPROVE → CONTROL : Useful for structured problem solving and process improvement.
KAIZEN - Small Improvements → Continuous Learning → Better Performance : Useful for creating a culture of continuous improvement.
LEAN - Identify Value → Remove Waste → Improve Flow → Create Value : Useful for process efficiency and customer or stakeholder value.

Champion First adds: **ASSESS → IMPROVE → CHAMPION**

The improvement methodology addresses the system. Champion First ensures that the **person develops alongside the system**.

8. The CHAMPION Stage: The final stage is the distinctive element of the Champion First philosophy. Achievement should not represent the end of development. Achievement should become the beginning of leadership.

A Champion is not defined only by medals, awards, rankings or certificates.

A Champion demonstrates:

- Capability
- Discipline
- Leadership
- Integrity
- Learning
- Improvement
- Innovation
- Cultural responsibility
- Community contribution
- Sustainability
- Willingness to develop others

Therefore:

- **Achievement creates recognition.**
- **Recognition creates responsibility.**
- **Responsibility creates leadership.**
- **Leadership creates wider impact.**

9. From Participant to Champion: Champion First establishes a developmental pathway:

PARTICIPANT
Participates in an activity.
↓
LEARNER
Acquires knowledge and skills.
↓
PRACTITIONER
Applies knowledge in real situations.
↓
ACHIEVER
Demonstrates measurable improvement.
↓
CHAMPION
Demonstrates excellence and leadership.
↓
MENTOR
Develops and supports others.
↓
COMMUNITY CHAMPION
Creates sustainable community impact.

This model creates a continuous leadership pipeline.

10. Champion First Continuous Improvement Cycle: The methodology can be represented as a continuous cycle:

ASSESS
↓
Understand the current state
PLAN
↓
Identify priorities and improvement objectives
IMPROVE
↓
Develop people, processes and capabilities
MEASURE
↓
Evaluate progress and outcomes
CHAMPION
↓
Recognize achievement and develop leadership
SHARE
↓
Transfer knowledge and best practices
SCALE
↓
Extend successful practices to others
REASSESS
↓
Begin the next improvement cycle

Therefore: **Champion First is not a one-time programme. It is a continuous development ecosystem.**

11. Champion First and Indigenous Knowledge: One of the distinctive applications of Champion First is the preservation and advancement of Indigenous Knowledge. Indigenous knowledge represents generations of experience relating to:

- Nature
- Agriculture
- Health and wellness
- Traditional games
- Sports
- Food
- Environment
- Crafts
- Community organization
- Local ecosystems
- Cultural practices
- Traditional technologies

Champion First encourages the movement of knowledge through five stages:

- **PRESERVE:** Protect traditional knowledge.
- **DOCUMENT:** Record knowledge systematically.
- **LEARN:** Transfer knowledge to younger generations.
- **INNOVATE:** Explore responsible contemporary applications.
- **CHAMPION:** Develop knowledge holders and community leaders.

12. Champion First and Artificial Intelligence: The emergence of Artificial Intelligence creates new opportunities for Indigenous Knowledge.

AI may support:

- Digital documentation
- Translation
- Knowledge classification
- Educational content
- Language preservation
- Research
- Data analysis
- Digital archives
- Learning platforms
- Cultural storytelling

However, technology should support knowledge holders rather than replace them.

The Champion First principle is: **"Technology should empower the Champion, not replace the Champion."**

Responsible implementation should consider:

- Consent
- Ownership
- Cultural sensitivity
- Data protection
- Intellectual property
- Community participation

Ethical use of technology

13. Champion First and Green Technology: Sustainability is another major dimension of the framework. Champion First encourages communities and organizations to develop Green Champions who can promote:

- Environmental awareness
- Resource conservation
- Sustainable agriculture
- Renewable energy awareness
- Waste reduction
- Water conservation
- Biodiversity protection
- Climate resilience
- Sustainable livelihoods

The objective is to connect:
Traditional Environmental Knowledge + Modern Green Technology + Community Leadership
to create sustainable development.

14. Seven Pillars of Champion First

Pillar 1 – Champion Mindset

Develop:

- Discipline
- Confidence
- Responsibility
- Resilience
- Ethical behaviour
- Continuous learning

Pillar 2 – Leadership

Develop individuals who can:

- Lead
- Mentor
- Communicate
- Make responsible decisions
- Build teams
- Serve communities

Pillar 3 – Learning

Promote:

- Education
- Skills
- Certifications
- Knowledge sharing
- Research
- Intergenerational learning

Pillar 4 – Performance

Focus on:

- Goals
- Measurement
- Quality
- Productivity
- Consistency
- Continuous improvement

Pillar 5 – Innovation

Encourage:

- New ideas
- Technology
- Entrepreneurship
- Digital transformation
- Problem solving
- Responsible experimentation

Pillar 6 – Culture

Protect and promote:

- Indigenous heritage
- Traditional knowledge
- Indigenous Games

- Languages
- Arts
- Community identity

Pillar 7 – Sustainability
Create long-term value through:

- Environmental responsibility
- Social impact
- Economic opportunity
- Community resilience
- Intergenerational development

15. Champion First Maturity Model: Organizations and communities can assess their development across five maturity levels.

- **LEVEL 1 – AWARE:** Basic awareness exists.
- **LEVEL 2 – DEVELOPING:** Training and capability development are introduced.
- **LEVEL 3 – PERFORMING:** Improvement activities are implemented and measured.
- **LEVEL 4 – CHAMPION:** Strong leadership, recognition and knowledge sharing are established.
- **LEVEL 5 – SUSTAINABLE CHAMPION:** Champions continuously develop new Champions and create long-term community impact.

The objective is therefore not merely to reach Level 5 once.**The objective is to sustain Level 5 and continuously develop the next generation.**

16. Champion First Measurement Framework: WIG can measure the framework using a balanced set of indicators.

People Indicators

- Number of participants
- Number of trained individuals
- Skills developed
- Certifications
- Leadership development
- Champion recognition

Performance Indicators

- Improvement percentage
- Quality improvement
- Productivity
- Participation
- Achievement
- Programme completion

Knowledge Indicators

- Indigenous knowledge documented
- Knowledge holders engaged
- Learning resources developed
- Youth trained
- Knowledge transferred

Community Indicators

- Community participation
- Youth engagement
- Women and community leadership
- Volunteer participation

- Social-impact projects

Sustainability Indicators

- Environmental initiatives
- Green practices
- Sustainable projects
- Resource conservation

Long-term programme continuity

17. Suggested Champion First KPI Scorecard: A WIG programme may establish a balanced scorecard containing:

Dimension	Example KPI
People	Participants developed
Learning	Training completion
Skills	Competency improvement
Performance	Measured improvement
Leadership	Champions developed
Culture	Knowledge preserved
Innovation	New initiatives
Sustainability	Long-term impact
Community	Beneficiaries reached
Knowledge Sharing	Mentors and knowledge transfer

The actual targets should be defined according to the specific WIG programme rather than applying one universal target.

18. Champion First Governance Model: A structured governance model can include:

WIG GLOBAL LEVEL
Framework ownership, standards and international coordination.
↓
PROGRAMME LEVEL
Programme planning, implementation and monitoring.
↓
ASSESSMENT LEVEL
Baseline assessment and capability evaluation.
↓
IMPROVEMENT LEVEL
Training, projects, mentoring and implementation.
↓
CHAMPION LEVEL
Recognition, certification and leadership development.
↓
COMMUNITY LEVEL
Knowledge sharing and sustainable impact.
This creates a clear accountability structure.

19. Champion First Recognition System: Recognition is an important part of the framework.
Recognition may include:

- Champion Certificates
- Champion Badges
- WIG Champion Awards

- Leadership Recognition
- Community Champion Recognition
- Green Champion Recognition
- Youth Champion Recognition
- Knowledge Champion Recognition
- Indigenous Games Champion Recognition

Recognition should be based on clearly defined criteria and documented evidence.

20. The Champion Multiplier Effect: A major objective of Champion First is to ensure that development does not stop with one person.

For example:
1 Champion
↓ develops
5 Learners
↓ develop
25 Participants
↓ influence
100 Community Members: The actual numbers will vary by programme; the principle is the important element: **One Champion should create more Champions.** This is the **Champion Multiplier Effect**.

20.1. Champion First and Established Improvement Methodologies: Champion First should be understood as complementary to established improvement methodologies.

Methodology	Primary Focus	Champion First Contribution
DMAIC	Structured problem solving	Develop people alongside process improvement
PDCA	Continuous improvement	Embed continuous learning
Kaizen	Incremental improvement	Build a culture of participation
Lean	Value and waste reduction	Connect efficiency with capability
TQM	Quality culture	Add leadership and community dimensions
Champion First	People + Knowledge + Leadership + Impact	Integrates the human-development journey

Champion First therefore provides an overarching **people-centred development philosophy** rather than attempting to replace technical improvement methodologies.

21. Champion First vs Conventional Improvement Thinking

Conventional Improvement	Champion First
Process first	People first
Problem focused	Potential + problem focused
Performance focused	Performance + capability focused
Improvement as objective	Improvement as journey
Achievement as endpoint	Achievement as beginning
Expert driven	Participatory
Organization focused	Individual + organization + community
Short/medium-term result	Sustainable impact
Measurement of outcomes	Measurement of people + outcomes
Success	Success + leadership + knowledge transfer

This comparison does not suggest that conventional methodologies are inadequate. Rather, Champion First provides an additional **human-development layer** that can operate alongside them.

22. Application Areas: Champion First can be applied across multiple WIG programmes.

- **Indigenous Games:** Develop athletes, coaches, officials and community leaders.
- **Education:** Develop students, teachers, trainers and knowledge champions.
- **Youth Development:** Develop young people through skills, leadership and community engagement.
- **Indigenous Knowledge:** Preserve knowledge and develop knowledge holders.
- **Sustainability:** Develop environmental and Green Champions.
- **Digital Transformation:** Develop Digital Champions and technology-enabled communities.
- **Research:** Develop Research Champions and knowledge networks.
- **Community Development:** Develop community leaders capable of sustaining local initiatives.
- **Organizational Excellence:** Apply Lean, Six Sigma, PDCA, Kaizen and other improvement tools through a people-centred framework.

23. A Practical Example: Consider a traditional Indigenous Games programme.

ASSESS
WIG evaluates:

- Participation
- Skills
- Coaching capability
- Knowledge of traditional games
- Documentation
- Youth participation
- Community involvement

IMPROVE
The programme introduces:

- Coaching
- Training
- Documentation
- Digital learning
- Leadership development
- Safety practices
- Performance improvement

CHAMPION
Outstanding participants become:

- Athletes
- Coaches
- Trainers
- Cultural ambassadors
- Mentors
- Community Champions

MULTIPLY: Champions then train the next generation.
Thus: **Traditional Knowledge → Learning → Practice → Achievement → Leadership → Community Impact**

24. The Champion First Formula: The philosophy can be expressed conceptually as:

CHAMPION FIRST = PEOPLE + KNOWLEDGE + IMPROVEMENT + LEADERSHIP + IMPACT

Where:

- **People** create the foundation.
- **Knowledge** provides capability.
- **Improvement** creates progress.
- **Leadership** creates multiplication.
- **Impact** creates sustainable value.

25. The Ultimate Philosophy: Champion First is based on a simple principle: **Do not develop programmes only to produce results. Develop people who can continuously produce positive results.** And further: **Do not create only winners. Create Champions who can create more Champions.** This philosophy connects individual development with organizational excellence, cultural preservation and sustainable community development.

Conclusion: Champion First represents a people-centred approach to excellence, continuous improvement and sustainable development developed by the **World Council of Indigenous Games (WIG)**. Built around the principle of **Assess → Improve → Champion**, the framework recognizes that meaningful and sustainable progress begins with people—their knowledge, capabilities, culture, aspirations and potential. While established methodologies such as **DMAIC, PDCA, Kaizen and Lean** provide powerful approaches for improving processes and performance, Champion First places equal importance on developing the people who create, sustain and multiply that improvement. The journey begins with **ASSESS**, establishing a clear understanding of the existing situation, strengths, capabilities, challenges and opportunities. It progresses to **IMPROVE**, where learning, innovation, leadership, technology and continuous improvement are used to create measurable progress. It culminates in **CHAMPION**, where achievement becomes a platform for leadership, mentoring, knowledge sharing and wider community impact. The framework is particularly relevant to Indigenous development because it recognizes that **Indigenous Knowledge, cultural heritage, traditional practices and community wisdom are valuable assets for the future**. Through responsible documentation, education, innovation and intergenerational knowledge transfer, these assets can contribute to contemporary challenges while preserving cultural identity. Champion First therefore moves beyond the traditional concept of achievement. A Champion is not simply an individual who succeeds; a Champion is an individual who **learns, improves, leads, serves, shares knowledge and enables others to succeed**. The ultimate objective is to create a continuous cycle:

Assess → Improve → Champion → Inspire → Empower → Transform

In this cycle, one Champion becomes a mentor, one mentor develops new Champions, and new Champions contribute to stronger individuals, organizations and communities.

WIG's vision through Champion First is therefore not merely to create more participants, achievers or winners. It is to build a global ecosystem of **Champions of Knowledge, Culture, Learning, Leadership, Innovation, Sustainability and Community Development**. **Champion First:** *Develop the person. Improve the system. Preserve the knowledge. Empower the community. Create the next Champion.*

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THE ART OF EFFECTIVE COACHING: BUILDING SKILLS, CONFIDENCE AND CHARACTER

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Abstract: Coaching is much more than teaching a skill or preparing someone for competition. An effective coach helps people understand their potential, develop their abilities, overcome challenges, build confidence, demonstrate discipline and eventually become capable of helping others. In an increasingly complex world, organizations and communities require more than conventional performance-management systems. Sustainable excellence depends on the ability to identify potential, develop capability, improve performance, recognize achievement and create leaders who can continuously improve themselves and others. The World Council of Indigenous Games (WIG) has developed the Champion First approach as a people-centred framework for excellence, capability development, continuous improvement, leadership and sustainable impact. Champion First is inspired by established improvement philosophies such as DMAIC, PDCA, Kaizen, Total Quality Management, Lean Management and Continuous Improvement, while introducing a distinctive emphasis on the individual, community, culture, knowledge and long-term impact.

The framework is built around three primary stages:

- **ASSESS:** Understand the current state, potential, capability, needs, strengths and opportunities.
- **IMPROVE:** Develop capability, remove barriers, implement improvement and create measurable progress.
- **CHAMPION:** Recognize achievement, develop leadership, share knowledge and empower the Champion to create wider impact.

The fundamental philosophy is: **"Develop the Champion first; sustainable success follows."** This article explains how anyone can apply this philosophy to become a more effective coach.

Keywords: *Effective Coaching, Art of Coaching, Champion First, Coaching Excellence, Sports Coaching, Coach Development, Athlete Development, Skills Development, Confidence Building, Character Development, Olympic Coaching, Olympic Coaches, Olympic Athlete Development, High-Performance Coaching, Coach-Athlete Relationship, Sports Leadership, Sports Performance, Athlete Psychology, Competition Preparation, Performance Coaching, Mentoring, Coaching Leadership, Personal Development, Team Development, Youth Development, Leadership Coaching, Resilience, Discipline, Motivation, Communication Skills, Feedback, Goal Setting, Independent Thinking*

1. What Is Coaching?

A coach is not simply someone who gives instructions.

A coach is someone who helps another person become better. That improvement may involve:

- skills,
- knowledge,
- physical ability,
- confidence,
- discipline,
- decision-making,
- leadership,

- teamwork,
- resilience,
- character.

A coach may work with:

- athletes,
- children,
- students,
- employees,
- teachers,
- community members,
- entrepreneurs,
- leaders,
- volunteers.

The environment may change, but the fundamental responsibility remains similar: Understand the person. Develop the person. Empower the person. This is the heart of Champion First.

2. Why Coaching Matters

People rarely reach their full potential completely alone.

A good coach provides:

- **Direction** when the learner is uncertain.
- **Correction** when the learner makes mistakes.
- **Encouragement** when progress becomes difficult.
- **Challenge** when the learner becomes comfortable.
- **Support** when confidence is low.
- **Accountability** when discipline is required.
- **Perspective** when emotions become overwhelming.

A coach therefore influences not only performance, but also development. Research involving Olympic swimmers found that athletes' perceptions of their coaches were associated with characteristics such as conscientiousness, openness to experience and emotional awareness and management. The study involved 38 Olympic swimmers who had collectively won 59 Olympic medals.

This reinforces a simple idea: **Technical knowledge is important, but the way a coach works with people matters too.**

3. Champion First: A Different Way to Think About Coaching

Traditional coaching can sometimes begin with a question such as:

“How do I make this athlete win?”

Champion First begins with a different question:

“How do I develop this person so that they can perform, grow and eventually help others?”

This creates a longer-term perspective.

The Champion First journey is: **ASSESS → IMPROVE → CHAMPION**
It is a continuous cycle, not a one-time process.

- **ASSESS:** Understand where the person is today.
- **IMPROVE:** Help the person move from the current state toward the desired state.
- **CHAMPION:** Recognize achievement and develop the person into a confident, responsible and independent contributor who can create impact.

Then the cycle starts again at a higher level.

Champion → Assess again → Improve again → Champion again.

This creates continuous development.

4. Stage One — ASSESS

Understand Before You Coach: One of the biggest mistakes a coach can make is starting to teach before understanding the learner.

Before giving advice, ask:

- Who is this person?
- What can they already do?
- What do they struggle with?
- What are their strengths?
- What motivates them?
- What are their goals?
- What barriers are affecting their progress?
- What support do they need?

The Coach's First Responsibility

Do not assume. Assess.

- A beginner and an advanced athlete should not receive exactly the same coaching.
- A confident athlete and a nervous athlete may need different approaches.
- A technically strong athlete and a disciplined but inexperienced athlete may require different development plans.
- The standard can remain high.
- The coaching approach should be appropriate to the individual.

5. What Should a Coach Assess?

A simple assessment can cover seven areas.

a. **Skill:** What can the person physically or technically do?
b. **Knowledge:** Do they understand what they are doing?
c. **Performance:** Can they apply the skill under real conditions?

d. **Confidence:** Do they believe they can perform?
e. **Discipline:** Can they consistently follow the required process?
f. **Character:** Do they demonstrate respect, responsibility and integrity?
g. **Leadership:** Can they eventually support and influence others?

This gives the coach a much more complete picture.

6. ASSESS Does Not Mean Judge

Assessment should not be used to label people.

The purpose of assessment is to identify the **starting point**. Imagine two children joining a Karate academy.

Child A:
- physically capable,
- confident,
- technically weak.

Child B:
- technically promising,
- physically less developed,
- very nervous.

If the coach treats both children exactly the same, one or both may struggle. The coach should identify the difference and create appropriate development opportunities.

Therefore: **Assessment is not about finding who is good or bad. It is about finding where development should begin.**

7. Establish a Baseline

A baseline is simply: **Where are we today?**

For example:

Area	Current State	Target
Technique	Basic	Advanced
Fitness	Moderate	Good
Confidence	Low	High
Discipline	Developing	Consistent
Competition skills	Beginner	Independent
Leadership	Beginning	Emerging

Without a baseline, improvement is difficult to measure.

8. Stage Two — IMPROVE

Turn Potential Into Capability

Assessment tells us where we are.

Improvement tells us what we do next.

A coach should convert the assessment into an action plan.

A simple improvement cycle is: **Goal → Learn → Practise → Feedback → Correct → Repeat → Measure**

This is closely aligned with established continuous-improvement thinking such as PDCA and Kaizen. But Champion First places an additional emphasis on the **person behind the performance**.

9. Teach the Fundamentals

Champions are not built by skipping fundamentals. A coach should ensure that the learner understands:

- basic movement,
- basic technique,
- basic rules,
- basic discipline,
- basic safety,
- basic decision-making.

A weak foundation creates problems later.

Example: A martial-arts student who learns advanced techniques without mastering balance, stance and movement may struggle when the situation becomes difficult. The coach must therefore resist the temptation to teach impressive techniques before fundamental skills are stable.

Master the basics. Then build complexity.

10. Demonstrate, Practise and Repeat

People learn differently, but practical learning often requires demonstration and repetition.

A useful coaching sequence is:

- **Explain:** Tell the learner what to do.
- **Demonstrate:** Show the learner what good performance looks like.
- **Practise:** Allow the learner to try.
- **Observe:** Watch carefully.
- **Correct:** Identify the most important adjustment.
- **Repeat:** Allow the learner to practise again.

This creates a simple learning loop.

11. Give Feedback That the Learner Can Use

Feedback should answer:

- **What happened?**
- **What should change?**
- **What should I do next?**

Weak feedback: “Wrong.”

Better feedback: “Your balance was good, but your supporting foot moved too early. Keep it stable and repeat the movement.”

The second statement gives the learner something they can actually use.

A simple feedback formula: Strength → Gap → Action

Example: “Your speed has improved. Your recovery position is still slow. Let's practise the recovery movement ten times.”

12. Correct Without Destroying Confidence

A coach must sometimes be demanding.

But being demanding does not require humiliation.

Avoid: “You are useless.”

Use: “This performance is below your current standard. Let's identify the reason and correct it.”

The standard remains high.

The learner's dignity remains protected.

A powerful coaching principle is: **Be tough on the problem, respectful toward the person.**

13. Build Confidence Through Evidence

Telling someone:

“Believe in yourself!”

is not enough.

Real confidence usually develops through experience.

The learner: **tries → struggles → practises → improves → succeeds**

That experience creates evidence:

"I can do this."

Therefore, coaches should create achievable challenges and gradually increase difficulty.

Confidence should be **built**, not simply demanded.

14. Teach People to Think

A coach should not answer every question.

Sometimes the better approach is to ask:

- "Why do you think that happened?"
- "What did you notice?"
- "What would you change?"
- "What would you do differently next time?"

This develops independent thinking.

Eventually, the learner should be able to solve problems without waiting for the coach.

That is a major transition:

- **From: "Tell me what to do."**
- **To: "I understand what to do and why."**
- **Finally: "I can decide and act independently."**

15. Prepare for Pressure

Practice and competition are not always the same.

A learner may perform very well during normal training but struggle under pressure.

Therefore, coaches should gradually introduce:

- time limits,
- competition simulations,
- decision-making under pressure,
- unexpected situations,
- fatigue,
- audience presence,
- scoring,
- realistic competition conditions.

Research into Olympic coaching has highlighted detailed preparation and simulation as important elements of high-level preparation, including efforts to reproduce aspects of competition environments.

The lesson is simple: **Do not prepare only for perfect conditions. Prepare people for real conditions.**

16. Olympic Case Study 1 — Bob Bowman and Michael Phelps

1. One of the best-known coach–athlete relationships in Olympic swimming is **Bob Bowman and Michael Phelps**. Bowman coached Phelps from a young age and became a major influence on his long-term development. The important lesson is not simply that Phelps won Olympic medals. The important lesson is the **development process behind elite performance**.

    - **ASSESS:** Understand the athlete's abilities, development needs and long-term potential.
    - **IMPROVE:** Build technical ability, physical preparation, mental preparation and competition readiness.
    - **CHAMPION:** Prepare the athlete to perform at the highest level and increasingly take ownership of performance.

Bowman's coaching career included multiple Olympic assignments, and the International Swimming Hall of Fame documents his role as Phelps's coach and his Olympic coaching history.

A particularly useful example comes from the 2008 Beijing Olympics.

During Phelps's 200m butterfly final, his goggles filled with water. Despite the unexpected problem, he continued and won the race. The broader coaching lesson is not that coaches should expect equipment failure.

It is: **Prepare the athlete to remain capable when circumstances are not perfect.**

This is Champion First in practice:
Assess the athlete → Improve adaptability → Champion under pressure.

17. Olympic Case Study 2 — Mike Krzyzewski and USA Basketball

2. **Mike Krzyzewski**, widely known as Coach K, coached the U.S. men's Olympic basketball team at the 2008, 2012 and 2016 Olympic Games. Team USA records document the team's Olympic success during this period and Krzyzewski's role as head coach.

    Team coaching is different from individual coaching.

    A team may contain many highly talented individuals.

    The coach must therefore answer: How do we convert individual ability into collective performance?

ASSESS
Understand:

- individual strengths,
- weaknesses,
- personalities,

- roles,
- team dynamics.

IMPROVE
Develop:

- communication,
- shared purpose,
- tactical understanding,
- accountability,
- teamwork.

CHAMPION
Create a team capable of performing collectively.

Lesson: Individual talent is not automatically team excellence.

A coach must build the environment in which individual talent can contribute to collective success.

18. Olympic Case Study 3 — Pat Summitt

3. **Pat Summitt** coached the U.S. women's basketball team to Olympic gold at the 1984 Los Angeles Games. The U.S. Olympic & Paralympic Committee notes her Olympic coaching achievement and later induction into the U.S. Olympic & Paralympic Hall of Fame.

   Her example demonstrates that coaching extends beyond technical instruction.

   A coach establishes:
   - standards,
   - discipline,
   - expectations,
   - culture,
   - accountability,
   - leadership.

Champion First Lesson

A coach should not ask only: “Can this athlete perform?”

The coach should also ask: “What kind of person is this athlete becoming?”

That is the difference between **performance coaching** and **people development**.

19. What Olympic Coaching Research Teaches Us
Olympic coaching research provides useful evidence for the Champion First approach. A study of Olympic swimmers found that athletes' perceptions distinguished world-leading coaches from world-class coaches on several psychological characteristics, including conscientiousness, openness to experience and emotional intelligence-related abilities.

Another body of research emphasizes that coaching is a relational process involving the coach, athlete and wider performance team. Modern high-performance environments can include physiologists, psychologists, nutritionists, physiotherapists, physicians and performance analysts.

This gives us an important principle: **A coach does not develop an athlete in isolation.**

Effective coaching may require collaboration.

20. Stage Three — CHAMPION

What Does "Champion" Really Mean?

Champion First does not define a Champion only as the person who wins a medal.

A Champion can be:

- a successful athlete,
- a disciplined student,
- a responsible coach,
- a community leader,
- a teacher,
- a volunteer,
- an innovator,
- a mentor,
- a person who creates positive change.

A Champion demonstrates development across multiple dimensions.

Champion = Capability + Confidence + Character + Contribution

Winning may be one outcome. But becoming capable of creating positive impact is a deeper form of achievement.

21. The Seven Dimensions of a Champion

1. Skill: Can the person perform?
2. Knowledge: Does the person understand?
3. Performance: Can they apply the skill under pressure?
4. Confidence: Do they trust their preparation?
5. Character: Do they demonstrate integrity, discipline and respect?
6. Leadership: Can they positively influence others?
7. Independence: Can they make decisions and act responsibly without constant supervision?
A strong coaching programme should progressively develop all seven.

22. Champion Means Contribution

- A person becomes more valuable when their knowledge is shared.
- A senior athlete can mentor a junior athlete.
- A successful coach can develop another coach.

- A skilled practitioner can teach the community.
- A Champion therefore moves through a progression:

Learner → Performer → Champion → Mentor → Leader

This is one of the most important ideas in the Champion First philosophy.

The journey does not end when someone becomes successful. Success creates a responsibility to contribute.

23. Recognize Achievement

Recognition is an important part of development. But recognition should not focus only on medals.

A coaching organization can recognize:

- Best Performance
- Most Improved
- Best Discipline
- Best Attendance
- Best Sportsmanship
- Best Team Player
- Best Leadership
- Best Mentor
- Best Community Contribution
- Best Innovation
- Best Character

This sends a powerful message: **There are many ways to become a Champion.**

24. Character Is Part of Performance

A person can be technically excellent but still require development in:

- discipline,
- respect,
- responsibility,
- teamwork,
- honesty,
- humility.

Therefore: **Performance tells us what someone achieved. Character tells us how they achieved it and what they do with that achievement.** A coach should develop both.

25. The Coach as a Role Model

Learners watch what coaches do.

- If the coach demands punctuality but arrives late, the lesson is contradictory.
- If the coach demands respect but insults athletes, the behaviour becomes the real lesson.
- If the coach expects continuous learning but never learns themselves, learners receive another message.

Therefore: **The coach is always teaching—even when the coach is not speaking.**

Your behaviour becomes part of your coaching programme.

26. The Champion First Coaching Cycle

The complete model can now be expressed simply:

ASSESS
Where are we now?
↓
IMPROVE
What must we develop?
↓
CHAMPION
What have we achieved and how can we create greater impact?
↓
ASSESS AGAIN
What is the next level?
↓
IMPROVE AGAIN
What can become better?
↓
CHAMPION AGAIN
How can the achievement create wider value?

This creates a culture of continuous improvement.

27. Champion First and Continuous Improvement

Champion First is compatible with established improvement approaches.

- DMAIC: Define → Measure → Analyze → Improve → Control
- PDCA: Plan → Do → Check → Act
- Kaizen: Continuous improvement through small, consistent improvements
- Lean: Create value and reduce unnecessary activities
- Total Quality Management: Build quality into the entire system
- Champion First adds a human-centred dimension: **Who is developing through the improvement process, and what will that person contribute next?**
  Therefore: **Process improvement + People development + Leadership + Impact** becomes a central Champion First philosophy.

28. Champion First in a Sports Academy

Imagine a young athlete joining an academy.

Month 1 — ASSESS
The coach evaluates:

- technique,
- fitness,

- discipline,
- confidence,
- learning ability.

Months 2–4 — IMPROVE
The coach develops:
- fundamentals,
- physical conditioning,
- technical skills,
- confidence,
- discipline.

Months 5–8 — IMPROVE
The athlete receives:
- competition simulation,
- tactical training,
- feedback,
- performance analysis.

Month 9 onward — CHAMPION
The athlete:
- competes,
- demonstrates sportsmanship,
- takes responsibility,
- supports junior athletes,
- begins developing leadership.

The athlete is no longer simply a student. The athlete is becoming a Champion.

29. Champion First in a School

The same model can be used outside sport.

ASSESS
Identify:
- learning strengths,
- gaps,
- confidence,
- interests.

IMPROVE
Provide:
- teaching,
- practice,
- mentoring,
- projects,
- feedback.

CHAMPION
Encourage students to:

- demonstrate their work,
- mentor peers,
- lead projects,
- solve community problems.

This transforms education from: **"Pass the examination."** to: **"Develop the capability to create value."**

30. Champion First in the Workplace

A manager can also become a coach.

ASSESS: Understand employee capability.
IMPROVE: Provide:

- training,
- mentoring,
- projects,
- feedback,
- responsibility.

CHAMPION: Prepare employees to:

- lead,
- innovate,
- mentor others,
- solve problems,
- improve processes.

The employee eventually becomes capable of developing others. That creates a multiplier effect.

31. Champion First in Indigenous Communities

The philosophy has particular relevance to community development.

A community may possess:

- traditional knowledge,
- indigenous games,
- cultural practices,
- crafts,
- ecological knowledge,
- local leadership,
- intergenerational knowledge.

The objective should not simply be to document knowledge. It should also be to **develop people who can protect, apply, teach and responsibly transfer that knowledge to future generations**.

Therefore:

- **ASSESS:** Understand the knowledge, people, needs and opportunities.

- **IMPROVE:** Develop capability, documentation, education, innovation and leadership.
- **CHAMPION:** Empower people to preserve knowledge, teach others and create sustainable community impact.

This connects Champion First with WIG's broader people-centred mission.

32. Coaching Children: Develop the Person, Not Just the Performer

Children require special care.

A child should not be defined only by:
- medals,
- rankings,
- competition results.

A young learner should also develop:
- enjoyment,
- confidence,
- discipline,
- friendship,
- respect,
- resilience,
- healthy habits,
- responsibility.

The coach should think long term. **Today's beginner may become tomorrow's athlete, coach, teacher or community leader.**

33. Parents Are Part of the Development Environment

For young athletes, the relationship between:

Child + Coach + Parent is important.

Parents should understand:
- training expectations,
- attendance,
- competition preparation,
- development goals,
- safety,
- behaviour standards.

The coach should also communicate appropriately and avoid creating unnecessary pressure.

The common objective should be: **Healthy development of the child.**

34. When a Learner Fails

Failure should become information.

Instead of: "You failed."
Ask:

1. What happened?
2. Why did it happen?
3. What was under our control?
4. What did we learn?
5. What should change?
6. What will we practise?
7. When will we reassess?

This converts failure into improvement.
Champion First principle: Failure is not the opposite of development. Unused failure is.

35. When a Learner Wins

Success should also be analysed.

Ask:

- What worked?
- Why did it work?
- Which preparation helped?
- What should we maintain?
- What should we improve next?

A medal should not end development. It should become the starting point for the next level.

36. The 10-Minute Coaching Conversation

A coach can conduct a useful development conversation in just ten minutes.

Minutes 1–2: Connect "How are you doing?"
Minutes 3–4: Review "What went well?"
Minutes 5–6: Assess "What was difficult?"
Minutes 7–8: Improve "What will you change?"
Minute 9: Commit "What will you practise?"
Minute 10: Champion "What is the next level you want to achieve?"

This creates a simple habit of continuous coaching.

37. The Coach's Weekly Self-Assessment

Every coach should assess themselves.

Ask:

1. Did I understand my learners?
2. Did I listen?
3. Did I explain clearly?
4. Did I demonstrate effectively?
5. Did I provide useful feedback?
6. Did I recognize improvement?
7. Did I develop confidence?
8. Did I develop character?
9. Did I encourage independence?
10. What will I improve next week?

The coach should follow the same Champion First model:
Assess yourself → Improve yourself → Champion others.

38. The 10 Habits of an Effective Coach

1. Prepare: Know the objective before training begins.
2. Observe: Watch carefully.
3. Listen: Understand the learner.
4. Explain: Use simple language.
5. Demonstrate: Show what good performance looks like.
6. Practise: Create opportunities for repetition.
7. Give feedback: Be specific and constructive.
8. Encourage: Build confidence through genuine progress.
9. Challenge: Gradually increase difficulty.
10. Empower: Teach the learner to become independent.

39. The C.A.R.E. Model Within Champion First

A practical coaching tool can complement the Champion First philosophy.
C — CONNECT: Know the person.
A — ASSESS: Understand the current state.
R — RESPOND: Provide the right development intervention.
E — EMPOWER: Build independence and leadership.

This can operate inside the larger: **ASSESS → IMPROVE → CHAMPION** framework.

40. The Complete Champion First Model

The complete philosophy can therefore be represented as: **CHAMPION FIRST**
ASSESS: Understand

- Person
- Skill
- Knowledge
- Potential

- Strengths
- Gaps
- Needs
- Context

↓

IMPROVE: Develop

- Skills
- Knowledge
- Fitness
- Confidence
- Discipline
- Performance
- Decision-making
- Leadership

↓

CHAMPION: Empower

- Achievement
- Character
- Leadership
- Independence
- Mentoring
- Knowledge sharing
- Community contribution
- Sustainable impact

↓

REASSESS: What is the next opportunity?

And the cycle continues.

41. The Most Important Lesson for Every Coach

You do not need to coach an Olympic athlete to practise excellent coaching.

You can begin with:

- one child,
- one student,
- one athlete,
- one employee,
- one team,
- one community member.

Ask: **Where are they today?**

That is **ASSESS**.

Ask: **What can we do to help them become better?**

That is **IMPROVE**.

Ask: **How can their achievement create value for themselves and others?**

That is **CHAMPION**.

42. Conclusion: The art of effective coaching is ultimately the art of **developing people**.

- A coach teaches skills, but a great coach develops capability.
- A coach provides instructions, but a great coach develops understanding.
- A coach prepares performers, but a great coach develops people.
- A coach celebrates winners, but a great coach develops Champions.

The **Champion First** philosophy provides a simple and practical way to achieve this:

ASSESS → IMPROVE → CHAMPION

- **ASSESS** the current state. Understand the person, their strengths, potential, needs and opportunities.
- **IMPROVE** the capability. Teach, practise, correct, encourage, challenge and measure progress.
- **CHAMPION** the person. Recognize achievement, develop character, build leadership, share knowledge and create independence.

Then begin again. Because development never truly ends. The Olympic coaching examples demonstrate that high-level coaching involves preparation, relationships, individual understanding, emotional awareness, detailed planning and the ability to develop athletes for demanding situations. Research involving Olympic coaches and athletes also emphasizes the importance of the coach–athlete relationship and the psychological qualities of effective coaching.

For WIG, Champion First extends these lessons beyond competition. It connects **people, performance, culture, knowledge, leadership and sustainable impact**. The ultimate objective is therefore not simply to produce someone who wins. It is to develop someone who can:

- **PERFORM.**
- **LEAD.**
- **TEACH.**
- **SERVE.**
- **INSPIRE.**
- **AND DEVELOP OTHERS.**

That is the deeper meaning of a Champion.

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Popular Games and Sports in the Heritage of the Nomadic Bedouins of the Moroccan Sahara

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Abstract: Heritage is a fundamental component of cultural identity and collective memory, reflecting the historical and social development of communities. Within Moroccan-African heritage, traditional games and sports represent an important form of cultural expression. Among the nomadic Bedouin communities of the Moroccan Sahara, these practices contribute to preserving cultural heritage, strengthening collective identity, and transmitting national and human values. They also enrich oral traditions and facilitate the intergenerational transmission of cultural knowledge, thereby ensuring its continuity and sustainability.
Keywords: Traditional games and sports – Moroccan Sahara – Nomadic Bedouins – Heritage preservation.

Introduction

The heritage of the nomadic Bedouins of the Moroccan Sahara includes many and varied popular sporting games, expressing the depth of the popular culture of the nomads in Moroccan Saharan society and its civilizational richness, such that popular sports, games and performative forms have constituted a rich heritage contributing to building the cultural, social and human edifice in the Arab world, Africa and the world.[41]

Play is considered one of the most important phenomena that theoretically relied on the effectiveness of human intervention to bring about structural change in its data, principles and purposes. On this basis, the nomadic Bedouins contributed to shifting the framework of popular games from what is instinctive to

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[41]* The Moroccan Sahara: The recovered Moroccan Atlantic Sahara is located in the extreme northwest of the African continent, connecting Algeria and Mauritania by land, and West Africa and Europe by sea. These regions occupy an important strategic position, which has made them a distinguished maritime passage since ancient times (...). The southern regions of Morocco, located between latitudes 20° and 28° north, extending along the Atlantic coast from the Akhenfiss inlet in the north to the Mauritanian border in the south, and from the Atlantic Ocean in the west to the Algerian border in the east, include the territories of Oued Ed-Dahab, Laayoune and Saguia el-Hamra, which, according to Morocco's latest regional division, fall within the Laâyoune-Sakia El Hamra region and the Dakhla-Oued Ed-Dahab region — territories that, due to climatic conditions, suffer from water scarcity in both quantity and quality. See: Zineb Mabsout (2018), Man and Water in the Moroccan Atlantic Sahara, Publications of the Al-Najah Association for Social Development in Laayoune, Afaq Foundation for Studies, Publishing and Communication, Geographic Knowledge Series, 1st ed., National Press and Papermaking, Marrakech, Morocco, p. 19.

what is socially and culturally acquired, developing their mechanisms from ones based on spontaneous emotion to mechanisms with a logical, ethical and crafted character. In play, the moment of playing offers an opportunity to enjoy the euphoria of play and physical, motor or symbolic expression through amusement, laughter and spectacle. Play also has an educational role in shaping the character of the nomadic Bedouins to be sound and balanced, to be emulated through educational, pedagogical and socio-cultural activities.

Image (1): The game of "Camel Lezz" during one of the camel-racing festivals.

The functional value of the phenomenon of play manifests in establishing a cultural and human project among the nomadic Bedouins of Moroccan Saharan society. It is a subject of interest and inquiry among specialists, experts and those interested in various fields, and an attempt to reveal the manifestations, types and functions of play among the nomadic Bedouin community, in order to investigate the image of play through oral popular memory — knowing that most of these games, whether old or modern, have not found their place in the present within the space of popular games engraved in the memory of the elderly, who continually recall them through folk tales and oral narratives, whose meanings and connotations have today become subject to disappearance into oblivion.

The nomadic Bedouins of Moroccan Saharan society have taken great care with popular games and sports, which have their importance and role in Moroccan culture, education and art; these nomadic Bedouins made these sports means of entertainment, amusement and recreation, indeed a manifestation of Moroccan-African-Hassani human cultural identity, despite the differences among these popular games from one to another in form, content and manner of performance. This difference, seen in the existence of men's games, women's games, and shared games, breathes life into this popular heritage and into the depth of these varied games, spanning mental, recreational and physical games. In the end, these games remain firmly rooted elements in the popular memory of the nomadic Bedouins of Moroccan Saharan society, elements that have remained steadfast and are still practiced to this day. This prompts us to raise pressing questions about the value of these popular games, which we summarize in the following problematic:

- What are the most important popular games and sports known to Moroccan-African Saharan society in the Moroccan Sahara?

Studying the subject of play is of great importance when probing the structural bedrock of the intangible cultural heritage specific to popular games and sports in Moroccan-African Saharan society, since it is necessary to conceptually frame the research paper around the theme of popular games in Moroccan Saharan society.

I. Popular Games and Sports in Light of the Conceptual Field of Study

African cultural heritage is among the fundamental elements expressing the specificities of African peoples, marked by richness and diversity, and constituting at the same time a common denominator between the Kingdom of Morocco and the various peoples of the world, including Latin America, with which we share deep historical ties. This is embodied in the momentum of diverse Arab-Latin cultural heritage transmitted through culture from generation to generation over several centuries, and in the many African languages of West Africa (Hausa, Yoruba, Zarma, Fulani, Bambara, Soninke, Songhai...). This attests to the richness and diversity of this African cultural heritage, which includes a purely local heritage stock resulting from great effort invested in authorship, documentation and recording — requiring special efforts to highlight and introduce it in a first stage, then to study it in order to benefit from its content in a second stage, in addition to rich African experiences in science, education, culture and the arts, which we, as Moroccans of the Maliki school, share extensively with most of Africa's peoples.

Research and writing on the presence of popular games in Moroccan-African culture is part of this effort to which we all aspire, as partners and custodians of a world culture that serves human civilization in all its manifestations.

1. The Concept of Play

The word "play" holds a distinctive place in Arab, African and human tradition, unlike the place it has occupied in scholarly writing — owing to the distinctive nature of the popular conception of the nature, purposes and dimensions of play. The Arabic dictionary places the verb "la'iba" (to play) opposite and contrary to the verbs "'amila" (to work) and "jadda" (to be serious), and situates the concept alongside the verbs "laha" (to be diverted) and "mazaha" (to joke). On this lexical basis, the Arabic dictionary defines the verb "la'iba" as an act meaning "to make light of."[42]

Play, linguistically: Ibn Manzur said: "Al-la'ib and al-la'b are the opposite of seriousness..." Ibn Faris noted: "Play is well known. Al-tal'aba means much playing; al-mal'ab is the place of play; al-lu'ba is a kind of play." In al-Qamus al-Muhit: "tili"ab and tili"aba: much playing... al-mal'ab: its place." Terminologically, al-Jurjani defined it in his Kitab al-Ta'rifat as "the act of children, followed by fatigue with no benefit" (...). Al-Ghazali, in Ihya' 'Ulum al-Din, said that a child should be permitted, after leaving the Qur'anic school, to play a wholesome game in which he can relax from the fatigue of study — so that preventing a child from play and wearing him out with constant learning kills his heart, dulls his intelligence, and embitters his life until he seeks any way to escape schooling altogether. In general Arab tradition, the notion of "play" overlaps with related concepts such as jesting and joking, and it is stated in Taj al-'Arus that "jesting and playing come from a single root."

As for Western sources, some of the earliest attempts to interpret play go back to the Greek philosophers: Plato was attentive to the value of play and used to distribute apples among children to help them learn arithmetic through play, while Aristotle stressed the necessity of encouraging children to play with the things they use in their daily lives, since this affects the development of their personalities.

Psychology scholars have likewise offered numerous and varied definitions of the concept of play, reflecting differing views on its nature, function, and the role it plays in the life of the individual and

[42]Abdellah Azigui (2025), Play and the Game in the Western High Atlas: The Idaouzeki Model, A Structural Approach, Dar Al-Salam Press, 1st ed., Rabat, p. 9.

society. The educational psychologist Jean Piaget considered play "a process of transforming incoming information to suit the needs of the individual, so that play, imitation and simulation form an integral part of the process of mental growth and intelligence."

In general, conceptions of play differ according to the various theoretical approaches that have addressed it from different angles — including behavioral, cognitive, constructivist, socio-constructivist and psychological approaches — so that the concept remains, operationally, an important behavioral activity that plays a leading role in shaping an individual's personality; play cannot occur without mental energy or bodily movement that helps achieve a sense of happiness.

2. Heritage (patrimoine)

Starting from UNESCO's General Conference in Paris in 2003, which affirmed the protection of popular heritage in general and cultural heritage in particular, in order to highlight the importance of documenting popular heritage, researching its origins, and preserving, protecting and promoting its transmission — the word "heritage" comes from the Latin hereditatem, meaning a father's estate. In English it is called "legacy," meaning what a person inherits, preserves and passes on to those who come after. Heritage enriches human culture and honors humanity. "Heritage" remains an inheritance of decades, preserving its original features and stable foundations despite every attempt at change that has sought to distort or alter it, and is marked by a set of creative qualities, being heritage built on roots that reach deep into history.

Heritage is a cultural form that is socially transmitted and endures through time, and includes not only what is said or narrated, but also what is done and made visible. Linguistically, heritage derives from the verb "waratha" (to inherit) — as one says "waritha fulanan," meaning so-and-so's wealth passed to him after death — and consists of what ancestors and forebears left to sons and grandsons, both material and immaterial; in its broad cultural sense, it is what predecessors left behind in the form of evidence and achievements across various intellectual, archaeological and historical fields.

Heritage as a whole is divided into tangible heritage — everything material, such as archaeological buildings, excavation finds, and museum holdings, which can be further classified into fixed monuments including historic cities, religious architecture, architectural landmarks, military fortifications, cemeteries, and so on — and intangible heritage, classified into intellectual heritage (comprising what earlier scholars, writers, thinkers and political figures produced, as witnesses of their times and creators of knowledge, sciences, and literary and other arts) and social heritage (comprising all societal behaviors and customs).

3. The Nomadic Bedouins of the Moors: Moroccan Saharan Society

This area extends from Wadi Noun to the Senegal River in the south, and from the Atlantic Ocean in the west to Mali in the east — an area the French used to call "Bilad al-Baydan" (Pays des Maures). This usage spread widely in their administrative reports and correspondence, as well as in the memoirs of travelers and explorers, so that the name "Bilad al-Baydan" acquired the status of a technical term, becoming the most commonly used expression in official documents, particularly among the French.

"The Baydan are light-skinned, Arabic-speaking people (Hassaniya dialect); it was likewise the French who coined the expression 'Etats Maures' for the areas along the river, in discussing the coastal side of Mauritanian lands during the eighteenth and nineteenth centuries. 'Maure' also denotes darkness of complexion, particularly in discussions of Moorish art, referring to the dark-skinned Arabs once present in Andalusia. The name 'Baydan' also appears with the geographer Abu 'Ubayd al-Bakri, and after him the

Moroccan traveler Shams al-Din Ibn Battuta, who restricted the designation 'Baydan' to the Sahara's inhabitants of brownish, sometimes whitish, complexion, distinguishing them from the rest of sub-Saharan Africa's dark-skinned inhabitants. This historical term developed from the 17th century onward with French travelers, who gave it a geographic meaning by restricting the concept of 'Baydan' (pays des Maures) to the area north of the Senegal River. Over time this term became widespread in agreements and correspondence between the French and the leaders and princes of the Baydani tribes, and al-Mukhtar Ould Hamidoun defined the concept of 'Bilad al-Baydan' for the region on the basis of unity of language, dialect, customs and traditions."[43]

The nomads are known for patience, nobility and courage, and for a high capacity for endurance, contentment, patience, and a strong memory for recalling the distant past. "The designation 'Baydan' (les Maures) underwent semantic development across the ages. In antiquity the Romans used the name 'Maure' or 'More' for the inhabitants of ancient Mauritania (present-day Morocco); in the medieval period the term became widespread to denote the Muslims who conquered Andalusia, and it is currently applied to the inhabitants of the Saharan region, which includes, besides the Islamic Republic of Mauritania, parts of the Republic of Mali, southern Algeria and the Moroccan Sahara. Mauritanian Baydan have retained this designation for themselves over time, until it became exclusively theirs; it remains common today to denote Arab Mauritanians (as distinct from Black Africans), with the common spelling 'Beydane' — replacing the letter 'ḍ' with 'ẓ,' as is customary among them."[44]

The word "Baydan" is pronounced in Hassaniya as "Beydane," the translation chosen by Paul Marty for the word "Maure," in place of "Arabs" or "Mauritanians." The French researcher Saugnier observed the Bedouin character, writing: "the Arab never complains, however great the loss he suffers; he is above misery, always patient with hunger, thirst and exhaustion, and yet always content, repeating the saying: 'This is God's will.'"[45]

On the courage of the Bedouins of Moroccan Saharan society, the Spanish military officer Bonelli writes: "They are skilled in combat, which is their natural domain; despite the thinness of their bodies they are very strong, their movements agile, and walking never tires them."[46]

II. The Presence of Popular Games in Nomadic Bedouin Society of the Atlantic Sahara

The French researcher Sophie Caratini states that "the history of the Arab person is defined through his past," and delving into the past history of peoples is one of the fundamental pillars for understanding their present and building their future.[47]

[43]Ibrahim El Housni (2010), The Oral and the Visual in Hassani Literary and Aesthetic Heritage, Research Series, Ministry of Culture Publications, Dar Al-Manahil Press, Rabat, p. 11.

[44]Mohamedou Mohamed Amin (2016), Documents from Baydani History: Unpublished French Texts (translation, verification and annotation), intro. Abdel Wedoud Ould Cheikh, Center for Saharan Studies, 1st ed., Dar Abi Regreg, Rabat, p. 35.

[45]Paul Marty (2001), The Baydani Tribes of the Basin and the Mauritanian Sahel and the Story of the French Occupation of the Region, Arabic trans. Dr. Mohamed Mahmoud Ould Weddady, World Islamic Call Society, 1st ed., National Books House, Benghazi, Libya, p. 4.

[46]Bonelli, Emilio (1887), Hernando, El Sahara, Péant e Hijos, Madrid, p. 133.

47Sophie Caratini (1989), Les Rgaybat (1610–1934), vol. 2, L'Harmattan, Paris, p. 10.

Image (2): The game of "Akhbit al-Shara" for men and youth at the Touiskî Festival, city of Assa.

The culture of Moroccan Hassani society abounds with tangible and intangible heritage material expressing the nature of the Saharan person and embodying his Saharan being, which can only be understood by understanding their heritage, rituals and cultural customs — heritage being "the principal determinant from which Saharan society drew its distinctive and rich culture and identity, together with the creativity and the cultural and social rituals practiced by its members in its light, and thence their transmission from generation to generation as general rules of life." The heritage of Hassani society encompasses all forms of human expression relevant to culture, art, literature and creativity.[48]

1. Manifestations of the Ritual of Play in the Popular Moroccan Culture of the Nomadic Bedouins

Play among the nomadic Bedouins of African societies varies according to age group, environment, and the objectives specific to each game. Children's play can accordingly be divided into several types: play defined by the number of participants (individual and group games), and play defined by physical build, represented in men's games, which are usually games requiring muscular effort. Women's games, for their part, are specific to women and are often marked by a feminine character. The nature of these games is determined by what each achieves in terms of recreational activity, physical-muscular development through movement, and flexible, calm play — which varies according to individual differences in Bedouin children's intelligence and their level of physical activity.

Image (4): A camel race for children at the Tan-Tan Festival.

Bedouin life shapes the development of popular games among the nomadic Bedouins of the Atlantic Sahara: the wave of influence begins with the space of play and its tools (sand, camel dung, sticks...) and

[48]Ahmed Ettayeb El-Alej (1994), Customs and Traditions in Morocco, vol. 1, Ministry of Cultural Affairs Publications, Salim Ikraf Press, Settat, p. 3.

extends further, reaching into the very depth of Bedouin life, so that we find ourselves before what might be called the limit of simulation — that is, the simulation of Bedouin life in the form of reality, invoking the central role of the mother inside the tent, and, more broadly, in popular culture (Um Dririy'a, Um Ghmayda, al-Mal...). This simulation connects to the symbolism of the human being, the land, and the animal, in ways that strongly shape the games themselves, since the life of the nomadic Bedouins is open to deserts, wastelands and arid wilderness that allow for a wide imagination, pushing them to create moments of happiness and euphoria to forget the heat and harshness of nature, and all the tame and predatory creatures that roam within it — creatures that leave their mark on the character of the nomadic Bedouins and on the heritage of their games, imbued with symbolic and connotative allusions drawn from the world of wildlife.

Heritage games carry within them many Bedouin values that document a rich and varied oral legacy, raising questions for us about space, humanity, nature and values — questions that may push these popular games and sports toward oblivion and extinction. Although not always bound by a condition of sanctity — being games that permit alteration and omission, and characterized by simplicity of tools and modest skill complexity — the practice of these popular games has recently declined, owing to the overwhelming tide of modernity affecting Bedouin culture, as well as sudden societal shifts that have touched popular culture in general and our Bedouin culture in particular, alongside attempts to replace heritage games with electronic games and technological forms of entertainment.

Image (5): A brochure for the Popular Games Festival in Assa Province, Atlantic Sahara.

2. Functions of Play among Nomadic Bedouin Children

The researcher Céline Petit observed that heritage games were generally divided, according to the seasons, into winter games and summer games — without this meaning that such games were never practiced outside their designated season. It is no secret that heritage games in Morocco were notably practiced according to a temporal pattern that implicitly respected the seasons, their influence generally greatest in winter, when humidity makes it easier to dig a hole in moist, damp soil without effort. Heritage games not covered by this sport-related division may instead be classified according to other criteria, such as the participant's age or sex:[49]

- Age criterion: children's games ("Bisso," "al-Drija"...) versus adults' games ("Dabli," "Ardoukh").
- Gender criterion: games specific to males ("al-Bi," i.e. marbles), versus females' games ("al-'Adhma," "al-Dakrisha"...), in addition to games shared between the sexes (such as "al-Seek").

[49] Same, pp. 71–72.

- Sport-intelligence criterion: mental games requiring computational skill and mental ability ("Dama"/checkers, "Meryas," "Domino"...).

All these categories of popular games carry, at their core, meanings and values, reflecting a type of play practiced either for gain and loss (dice games), or purposeful play aimed at acquiring noble human values and cooperation — while also allowing individuals and groups a sense of belonging (tribal belonging, for example), and offering the security to play with complete ease, for "man is the son of his environment," as in the game of "al-Lezz." These are strict Bedouin values that forge courage and bravery, unlike some modern games practiced inside "digital homes" through electronic devices, which require connection to the world wide web with its attendant health consequences — whereas what distinguishes popular games is that they are practiced individually or collectively, free of charge, in an open, free, social space.

Some regard play as a waste of time and a disregard for time, while others see it as fulfilling positive functions and purposes for both individual and society. Play is important for the child: it strengthens the body, develops the mind, enhances intelligence, and achieves an integration of social, emotional and mental functions that helps the child solve problems, create and innovate.

Through the function of play, a child can discover himself and the environment in which he lives. Its benefits include the following:

- Physical level — movement and motor skill: active, physical play must leave a deep imprint on the child's psyche and personality through the acquisition of physical fitness, sustained by the continued practice of these active heritage games.
- Educational level — pedagogy of play: play allows the individual to absorb much from his surroundings and society; commitment to the rules and order of the game contributes to shaping his personality and forming him as a member of society. Play is a sound form of educational organization, and an effective means for developing observation, activating memory and thought, and cultivating creative imagination and will.
- Psychological level — psychological flexibility: play does not fulfil physical and educational functions alone, but also achieves psychological balance, with effects on both the individual and the group (group dynamics). A child's psychological makeup is shaped by the nature of the game, the place of play, and his attachment to it, and by his interaction with it through pain, smiling, resilience, and attempts to take on roles that differ from his real personality.

2. The Most Important Popular Games among the Nomadic Bedouins - the Veiled Ones - of the Atlantic Sahara

Popular games constitute one of the important elements of popular heritage, and an important part of the collective memory and collective mind of nomadic societies. They are a product of cultural, social and human formation, and a reflection of the Bedouin environment and prevailing way of life; play thus contributes effectively to building social character and to shaping it in its national, social and psychological dimensions.

In this light, we will examine the reality of popular games among the nomadic Bedouins through a thematic approach, taking into account a number of important points for each category of these popular games, whether men's, women's, or shared between the two, drawing on what oral tradition records and passes down from generation to generation.

Men's Games among the Nomadic Bedouins of the Atlantic Sahara

The game of Arah: classified among the men's and group games known to nomadic Bedouin society, with a character befitting the masculine domain. The game of "Arah" is prepared both physically and mentally,

given the nature of the game, which requires precision, speed, quick wit, and the capacity for patience and endurance without haste. "It was the favorite pastime of Bedouin youth: placing one of them in the middle of a circle and provoking him with shouts and jabs," and this game requires great agility and nimbleness, enjoying great esteem among nomadic Bedouins as one of the finest expressions of their amusement and entertainment.[50]

Players of "Arah" wear "Arab trousers," secured with a "lkashat" to aid jumping, speed and directing blows, while the upper body is wrapped in an "afrwal-al-hawli." Five or more players form a circle around the opposing player at its center, who must keep one foot firmly on the ground and use the other to strike at the players harassing him. To hit his target, the player must remain fully alert and focused, gauging speed to land the blow and score. Once struck, the player who delivered the hit takes the opponent's place, joining the rest of the players inside "Arah." The playing space is an enclosed circle, and the game is played during leisure time (while camels graze, at dusk, or during celebrations), often before the women, to display a form of vigor, strength, skill and intelligence. According to oral tradition, some blows proved fatal, causing injuries of varying severity that sparked disputes between tents and tribal conflicts.[51]

The game of Akbiba: a youth men's game played in groups of about four players per team or more. Before play, a draw known among the Bedouins as "Khbit al-'Ud" (stick-striking) determines which team will carry the other on the backs of its players. The chosen players then mount, and the game proceeds with the exchange of a ball ("al-Kubba") among the players at close range, with the opposing team's players attempting deliberate feints. The moment the ball touches the ground, the mounted players fall and flee toward "al-Qam" or "al-Kara" — a safe refuge — while the opposing team gives chase, hurling the ball after them; whoever is struck by it must switch into the mounted position, and so the game continues. Akbiba is played near the tents, wells and watering places where the children of the encampment gather while herding livestock, and it relies on focus and speed, teaching riding skills in preparation for a later stage involving camels and horses.

Image (6): The game of Akbiba for children.

The game of Meryas: one of the modern popular men's games, alongside domino and "Toti." It depends on four competing suits — "al-Beek" (spades), "al-Kor" (hearts), "al-Karo" (diamonds) and "al-Trifel" (clubs) — such that when a player calls "beek," it beats all the cards of "al-Kor," "al-Karo" and "al-Trifel," and likewise for the suit that follows it in play.

[50]The game of "Lkeza" is a famous popular game among the people of the Sahara, who call it "Arah."

[51]"Afrwal," "al-Litham," "al-Hawli," the turban: a piece of indigo cloth about three and a half meters long.

The game of Domino: made up of 28 pieces called by the nomadic Bedouins "al-Fitcha." Usually two teams compete, each of at least two players; it is rare for only two individuals to compete, and it cannot be played by three. The method of play relies on each player or team managing their share of seven domino pieces well, and trying to get rid of them before the opposing team does.[52]

The game of Dama (checkers): a gridded board drawn by the Bedouins on sand or stone ("al-Batha"), with more than eighty squares. It is played by two people, surrounded by a crowd of supporters who encourage the players to exert their utmost effort to win. In the Bedouins' view, this game sharpens their sense of skill, pushes them toward focused mental confrontation, and cultivates agility, quick wit, precision, speed of response, and the ability to detect an opponent's weaknesses in order to win — all while providing amusement, entertainment and pleasure.

Image (7): The game of Dama (checkers)

The game of Dabli: the nomadic Bedouins classify it as a muscular game based on "al-Adra'" (arm strength). A group of young men form a standing circle, with a volunteer bent in the middle, almost sitting on his feet. The other players race to land light blows on him, while he tries to fend them off without standing up on his own initiative. If he succeeds, he joins the standing circle, and the player whose blow he parried must immediately take his place in the center.

The game of Ardoukh: a popular game that develops the nomadic Bedouins' muscular strength and agility, resembling Roman wrestling. Bouts are usually held in an atmosphere of enthusiasm on a dirt arena, accompanied by popular shouts and cries of encouragement. It begins with a player trying to pull his opponent toward him, tuck his head under his arm, and lock his opponent's leg to score a point. It relies on strength, agility and control of the opponent, requiring the player to remain alert in both attack and defense; usually only specialists- those known as having "strong arms" among the nomadic Bedouins - dare to practice this game.

The game of al-Lezz- Camel Racing: the Bedouins were closely bound to the camel, which held a special place and symbolism for them, representing a symbol of life and fertility and a source of milk, meat, hide and wool. It was, for them, a cure for illness and depression, restoring their strength and vitality. For this reason they organized what they called "Lezz al-Ibil" (camel lezz), or "al-Salaf," in the countryside and at celebratory occasions such as "qiran" and wedding festivities, when camels are gathered to compete in races ridden by the nomadic Bedouins - "Afkarish," Bedouin youths skilled in camel riding. The game of

[52]The game of Domino: first appeared in China around 1120 CE, known as "the dotted cards." The word "domino" derives from a Latin word meaning "lord" or "master," and it became a popular game played by men for amusement and entertainment.

"Lezz al-Ibil" was historically associated with nomadic Bedouin society in Assa, within a set of celebratory traditions, rituals and customs.

Image (8): A camel-lezz competition.

This game persists despite the spread of settlement, urbanization and globalization, alongside efforts to establish legal frameworks regulating "Lezz al-Ibil" within national and international meetings and competitions, in order to preserve this traditional popular heritage. "Lezz al-Ibil - al-Salaf" remained strongly present in nomadic Bedouin society among the tent-groups ("al-Farkan"), and at wedding and "ta'rkiba" celebrations, where it would be brought to the racetrack.

Women's Popular Games among the Nomadic Bedouins

The game of Lizar/al-'Adhma (the Bone): the Bedouins attribute the name to its being made from goat bones. Al-'Adhma is among the most famous popular games among nomadic Bedouin girls ("Tafilat"), and the most expressive of their attachment to their feminine world. The girls choose fabric ("Lakhnat") to make clothes for the bones as if they were dolls, give them braided hair, and adorn them with jewelry ("al-'Akik" and beads), so that al-'Adhma resembles a miniature Baydani woman, given a feminine identity for talk, companionship, dialogue, laughter and tears.

The game of al-Dakrisha: meaning "the daughter of al-'Adhma" in the popular heritage of the nomadic Bedouins. Bedouin girls braid its hair as if it were a real girl, then fashion various figures (dolls) representing their male and female friends, dressed in "al-Milhafa," "al-Yizar," "al-Dara'a," "al-Nakisha" and "al-Litham."

The game of al-Seek: one of the most famous women's popular games among nomadic Bedouins. Its pieces consist of a mound of sand shaped like an animal's back ("al-Wich"), about 60 centimeters long, called "Labra." The game requires "seekat" (sticks), as well as tools made of stones, camel dung, small twigs, or reed pieces, with which each team advances along "Labra" toward the opposing team, trying to force them out of the competition circle. The "seekat" are eight sticks, each between 35 and 40 centimeters long, usually made of reed or wood.

Image (9): The traditional women's game of al-Seek, played on sand.

Each stick is called a "seeka," plural "asyak"; each has two faces - an outer face, and an inner, curved, colored face - with a smooth, single-colored back, laid out on a sand board marked with balanced lines called "Labra," divided into two halves, each team's half marked by a piece parallel to the other's, between which run two lines of dots and pits along which the "seek" pieces move. The rules do not allow a player from either team to move on "Labra" unless a throw lands the "seekat" all showing a single face ("azhar al-seek"). Movement then proceeds through the pits toward the opposing team, according to the number of points scored based on how the "seekat" land during play. "Anyone contemplating the elements that make up this game will clearly see the convergence between them and the players' sense of belonging to the region's geographic and environmental surroundings, which gives the game its popularity and its intrinsic value."[53]

Shared Popular Games — Women's and Men's — among the Nomadic Bedouins

The game of Khamisa (jacks): one of the most widespread popular games among nomadic Bedouins, played with five small pebbles. It relies on skill, intelligence and concentration: the player must catch the stones as they are thrown into the air, with calculated precision, without letting any fall to the ground ("al-Batha") - dropping a stone counts as a defeat before the opponent.

The Kadra dance: a popular dance built on body language as the source of movement and its unfolding in space, within the many and varied choreographic contexts of the folkloric scene, based on the semiotics of individual dance within this ritual, celebratory practice expressed through word, tune, movement and poetic speech - forming an artistic tableau of deep human meaning among the Bedouins. It is a dance closely bound to Moroccan-African folkloric roots, in which voice, movement and rhythm harmonize and the performance moves toward spectacle. According to many specialists in Hassani popular folklore, the Kadra dance takes its name from the round vessel used as a musical instrument - a clay jar whose mouth is covered with a piece of goatskin.

Image (10): The Kadra dance performed by a Bedouin woman at the Touiskî heritage festival in Assa.

During the dance, its symphonic rhythm takes shape through striking the "Kadra" with two sticks the singer calls "al-Maghazil," producing a musical rhythm in harmony with the clapping. The dance begins with the formation of a circle, at whose center stands a man called "al-Nakkar," whose task is to strike the musical rhythm required by the Kadra performance, and who also directs the rest of the musical group, drawing their attention to any lapse that may occur during the chanting ritual, from within the circle where he is positioned. Alongside him, another key figure is the lady dancer ("al-Rakkasa"), who joins the celebratory folkloric scene as an essential part of sustaining the ritual performance before those present,

[53]Lamdassam El Wafi (2003), The Game of "Seek" in Ramadan in the Saharan Provinces, Between the Warmth of Gathering and the Pleasure of Competition, Draa Magazine, No. 4, Top Press, November, p. 18.

after being prepared backstage by the lady "al-Khadim/al-Mu'allima" - in terms of certain adornment specifications and the rules of the game, including not opening her eyes, within the space allotted for the dance and visible to those around her. She then begins to dance within a continuous, controlled movement, circling on her knees, while the rest of the musical group remain in place, swaying their shoulders right and left ("al-Tadawih") within the spaces the dancer traces toward them, moving her fingers and turning her palms - while "al-Nakkar," following the ritual, moves calmly and steadily within the circle so as to remain facing the dancer and connected to the musical instrument, preserving the ritual, celebratory spectacle of the Kadra dance.[54]

Narratives / Popular tales: the popular tale is the offspring of human societies, and nomadic Bedouin society is an integral part of Moroccan Saharan society, fertile and rich in vast imagination, in strange narratives and varied popular tales embodying an age-old, ongoing struggle between good and evil, drawing characters and narrative symbols into conflict with other beings from strange worlds woven of imagination, sometimes called ghouls or jinn. The narrative's hero remains present in these tales, embodied in creatures inseparable from the desert environment (gazelles, hyenas, wolves, snakes such as "Lahnusha" and "Lfa"'...) - a strange animal world that, though woven of imagination, remains connected to real worlds inspired by desert life.

Riddles: "at-Tahaji"/puzzles: nomadic Bedouin society in the Atlantic Sahara is famed for many riddles, often the specialty of an elderly person ("kahl"), whose life experience is rich in riddles, puzzles and adventures - narrative material full of concealment, mystery, wonder, questions and experience, and proverbs conveying the meaning of Hassani values.

The Shartat dance: Shartat is a legendary figure among the nomadic Bedouins, and a dance is attributed to him. The Bedouins take on the role of Shartat by wearing a costume evoking him, and "the masked one" performs dances alongside his wife - herself a disguised character, symbolizing intelligence and foolishness at once - amid Hassani musical rhythms. During the folkloric scene, Shartat's wife repeats the words "Shartat yidour yuklni," meaning "Shartat is looking for me to eat me," spoken from the wife's perspective.

Image (11): A depiction of the Shartat dance at one of the Hassani folkloric celebrations.

The Lbelouh dance: a popular dance specific to Bedouin women, performed during a musical ritual, in which the dancer carries a drinking vessel ("Kadha") in her hands and moves toward another girl sharing the same dance, referring to the process of "al-Belouh" - the fattening process undergone by Bedouin girls to attain a plumpness considered fitting for their bodies, a practice still seen in nomadic society, with Bedouin women repeating the well-known phrase: "Amnati ndour nbalhhum."

[54]"Al-Nakkar": the person responsible for striking the drum.

The dance of "Shibani Yloud Ljmalwa": a popular dance associated with an elderly man, symbolizing a journey in search of a shepherd's camels that have strayed. It is expressed through a series of symbolic, silent, sorrowful bodily gestures, accompanied by those present repeating, before this ritual dance scene: "Shibani al-oud ljmalwa."

III. The Popular Games of the Nomadic Bedouins: A Civilizational and Human Legacy That Refuses to Be Forgotten

1. The Importance of the Cultural Heritage of the Nomadic Bedouins as a Symbol of Human Civilization

Cultural heritage is "the treasure of the nation," and is one of the important means by which the nature of a society and its environment is identified, revealing the specificity of each nation as a true record of its various social, intellectual and cultural dimensions. It carries a society's concerns and hopes, and expresses part of its spontaneous, unassuming life. Because the practices of early humans were inherited and carried on by their descendants, they came to have real value and benefit, and because these people immortalized them in their own, primitive way, they came to form a cultural and literary legacy, and, given the depth of its authenticity and its power to link past, present and future, heritage became an inevitable necessity in the life of the individual.[55]

Image (12): Offering dates and milk to guests at celebrations of popular games.

2. Why We Preserve Intangible Cultural Heritage Today

"It is not only women who tell these stories to children at night, but elderly men as well, and children delight in hearing them from people gifted with exceptional storytelling talent. These tales blend with talk, rituals, genealogical history, and warriors' personal memories - all of which contributes to shaping the consciousness of the young." For this reason, oral heritage must be cared for, and efforts intensified to safeguard and protect it, with responsibility shared by all official bodies across Arab, Latin American and other nations, in order to preserve the historic message of popular heritage connected to popular games worldwide.[56]

In light of the above, we offer the following recommendations in service of heritage:

- Carrying out in-depth studies and research on oral popular heritage, in service of humanity;
- Promoting scientific heritage tourism across Morocco and the world;
- Creating a continent-wide legal framework to protect cultural heritage as a lever for dialogue, development and investment;
- Enlisting the role of various media in serving the message of African and human heritage;

[55]Saidi Mohamed (1998), Popular Literature Between Theory and Practice, University Publications Office, Algeria, p. 17.

[56]Same source, p. 252.

- Carrying out comprehensive documentation and inventory of heritage in the form of a comprehensive digital cartographic record of world heritage;
- Establishing strict laws to criminalize acts harmful to heritage amid wars and international conflicts;

3. Means of Preserving Tangible and Intangible Popular Heritage Today

Researchers and experts in the field of heritage bear direct responsibility for its preservation, which calls for formulating recommendations that specifically serve heritage, alongside UNESCO's adoption of the mission of preserving heritage as a human and civilizational legacy. These recommendations include the following:

- Invoking cultural heritage in literary, artistic, sporting and media works;
- Establishing ethnographic museums to preserve intangible heritage;
- Recognizing the importance of printing, publishing and documentation, and maintaining neutrality in writing;
- Encouraging scientific research on Arab, African and world cultural heritage;
- Safeguarding and protecting heritage in ways that advance the documentation and valorization of the knowledge connected to it;

In conclusion, the relationship between heritage, development and investment, for humanity at large, is a necessary and consequential matter for those working in the field of heritage. Opening discussion on the theme of popular games and sports offers a new avenue for those interested in and working on the subject, in service of humanity. So that this legacy does not remain distant from future generations, an alarm must be sounded for nomadic Bedouins across the world, since this civilizational and human heritage is passed down by generations, from one to the next.

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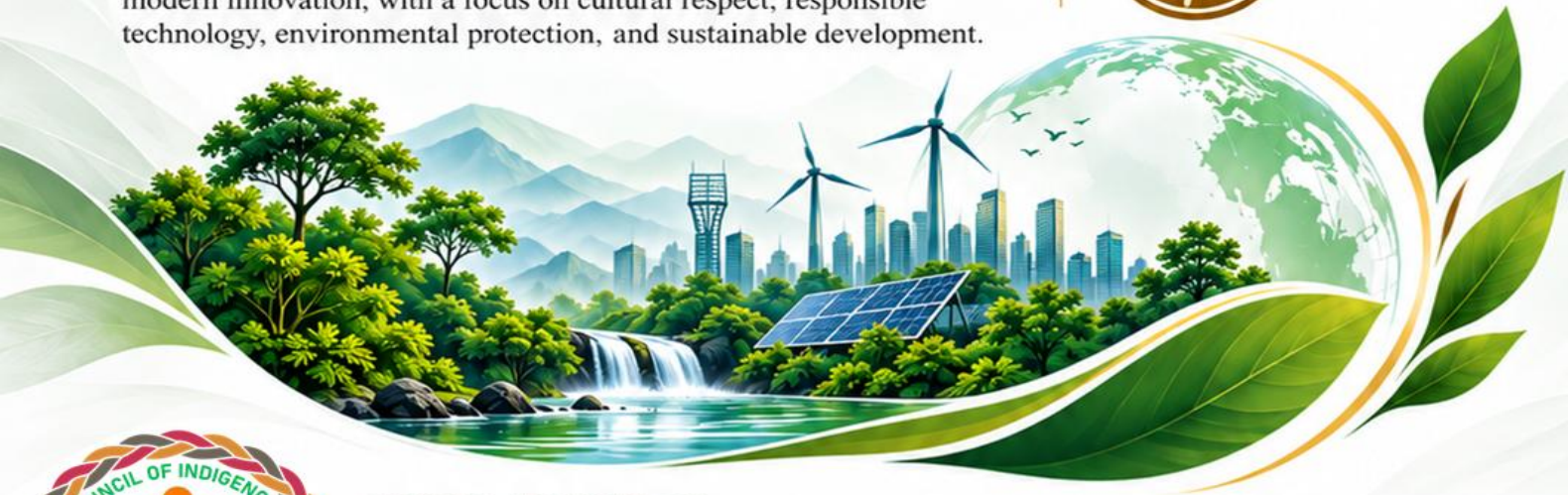

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