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TRADITIONAL ECOLOGICAL KNOWLEDGE IN FORESTRY: TRENDS AND PROSPECTS

TRADICIONALNA EKOLOŠKA ZNANJA U ŠUMARSTVU: TRENDOVI I IZGLEDI

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Abstract

Ensuring the protection of natural environments is vital for the prosperity of future generations. In all forested regions of the globe, local traditions have been essential in creating healthy human-forest relationships. These practices can be summed up as Traditional Ecological Knowledge (TEK), forming an increasingly important factor to consider when developing practical and effective forestry policy. Despite the international community's gradual acceptance of TEK as a valid policy guide, the field of forestry in many regions of the world continually ignores this crucial concept. As such, many forest ecosystems are harvested in ways that do not reflect the values of local - and often indigenous - communities, resulting in socio-economic divisions and unsustainable environmental degradation. This paper examines the state of TEK in the forestry sector through conducting a comprehensive literature synthesis of thirty-six published papers. Based on trends within the selected literature, the majority of articles identify TEK as providing social, political and economic benefits to the forestry sector. The literature also indicates that governmental and non-governmental forestry actors have and continue to neglect TEK as a policy tool, with 72% of the works examined directly discussing the damaging effects of this trend. The implications of these results are discussed in the light of temporal issues relating to the forestry sector, providing an impetus for both academics and leaders in forestry to consider the importance of TEK in policy and research.

Key words: forestry governance, indigenous rights, literature synthesis, policy frameworks, socio-economics, traditional ecological knowledge (TEK)

1. INTRODUCTION / UVOD

Historical narratives of mainstream environmental sciences have often been marked by anthropogenic detachment from ecology (Ives et al., 2018). In many past and present-day initiatives, conservation circles push the notion that human settlements must be separated from the natural environment (Ives et al., 2018; Miller, 2005). While creating spaces to conserve nature in its unaltered form is crucial for sustainable development, there are fundamental flaws to this narrative. Firstly, it imposes a pessimist lens on human development and infrastructure (Swaisgood & Sheppard, 2010). By claiming that nature cannot exist within

man-made settlements, communities fail to uphold key values and principles of sustainable development. Secondly, the division of human and non-human growth discourages humanity from innovating on current infrastructural and economic systems (Kopnina et al., 2018). If there is no way for nature to coexist within civilization, then there are less compelling reasons to pursue eco-friendly economic systems. Considering these flaws, the core goals of sustainable development cannot be achieved if conservationists continue to employ this divisive ideological framework in policy. This dilemma is particularly relevant to the forestry sector since it relies on the use of natural capital for human welfare (Marchetti et al., 2014). There is no way to adopt sustainability in this sector without accepting and embracing the relationship between human and natural growth. Despite this, there remains a lack of consensus on how to best support this relationship (Ives et al., 2018; Kopnina et al., 2018).

Many debates have emerged on how to best support the relationship between humans and nature, whereby most conversations focus on how humanity should address the current political-economic systems in place (Lockwood, 2018). Many conventional right-wing narratives promote the maintenance of present-day capitalist structures, encouraging infrastructural innovation in a neoliberal setting. In opposing political circles, there is a greater push to remove capitalist approaches from political and economic decision-making, instead adopting more socialized approaches to human development (Lockwood, 2018). One emerging framework that is often excluded is the Traditional Ecological Knowledge (TEK) perspective, which shifts the focus away from politico-economics towards philosophies of communal infrastructure (Ramos, 2022). In this line of thought, sustainability is achieved when anthropogenic settlements can quantify their impacts on the environment, ensuring that natural systems can sustain the community's existence. Nicolas Houde (2007) has been influential in organizing the core principles of TEK, developing "six faces of Traditional Ecological Knowledge".

These are:

1. Factual observations, classification and system dynamics
2. Management systems
3. Factual knowledge regarding past and current uses of the environment
4. Ethics & values
5. Traditional ecological knowledge as a vector for cultural identity
6. Cosmology

While TEK is often used to solely discuss Indigenous knowledge, the term can apply to a much broader concept of ecological governance. According to Hernández-Morcillo et al (2014), TEK refers to "a body of knowledge and beliefs about the relations of specific human societies to the local environments in which they live, as well as their local practices for ecosystem use and stewardship." Ethnic groups that are both Indigenous and non-Indigenous have shown and continue to demonstrate many examples of highly valuable traditional governance practices and systems in the natural environment (Hernández-Morcillo et al., 2014). Therefore, adopting a global approach to the analysis of TEK in forestry is crucial to this research, ensuring that perspectives from traditional communities throughout the world can be adequately evaluated and assessed on the basis of their contribution to the forestry sector.

To assess the state of TEK in the modern forestry sector, this paper will synthesize a selection of research conducted throughout the globe, analyzing relations between local communities and wider governmental and scientific communities in the context of various forest-based industries. Considering the historical and contemporary narratives surrounding ideological clashes between these two groups, this synthesis will focus on two dimensions of TEK in the forestry sector in the literature. First, it will explore how TEK contributes to development in the forestry sector, namely through: 1. Social development; 2. Political development; 3. Eco-

nomic development. Second, it will investigate how TEK has been received by mainstream forestry actors in the contemporary forestry sector.

2. MATERIAL AND METHODS / MATERIJAL I METOD RADA

As a synthesis paper, this research aims to evaluate the overall status of TEK in the forestry sector, showing how its current realities have affected the forestry sector as well as potential areas for improvement. Generating a sufficient perspective on this topic requires the employment of different perspectives and avenues of both traditional knowledge systems and forestry. While TEK is often a term used to exclusively evaluate the practices of UN-recognized Indigenous groups, this research takes a broader approach to the term, adopting a wider systems-based approach to traditional management systems, and encompassing any localized community with culturally-inherited practices related to the forestry discipline that reflect the core tenets of sustainable development as identified in the Brundtland Report (Burton, 1987). With this overarching definition of TEK identified, the selection of specified research can be identified. When selecting literature for this synthesis, the following criteria have been applied to the evaluated works:

1. Research places focus on a localized community or ethnic group involved with forestry-related practices.
2. Research makes direct reference to the traditional qualities of communities with relation to forestry, whether that tradition comes in the form of theology, traditional scientific systems or generationally-inherited techniques.
3. Research makes a distinction between the said local TEK-based community and non-traditional governmental actors, specifically in relation to forestry.
4. Research has been published by a peer-reviewed journal or accredited post-secondary institution.

When categorizing the particular demography of these articles, four particular markers have been examined and cataloged for each piece, namely: 1. Region(s) examined; 2. Work format; 3. Research type; 4. Forestry sector(s) covered. Regional analysis is broken down into five geographic regions, namely North America, Latin America, Europe, Africa, and Asia/Oceania (Figure 1). When examining the work format, a total of four different types will be presented, namely journal articles, academic publications, book chapters, and conference papers. Research type evaluates whether the research was conducted in a primary format, drawing from direct data collected by the authors, or a secondary format in which authors evaluated pre-existing data and research. The forestry sectors addressed in the selected articles fall into a total of seven categories, namely holistic forest governance, biodiversity tracking, agroforestry, climate change resilience, sylviculture, ecotourism and broad forestry usage.

3. RESULTS / REZULTATI

A total of thirty-six published manuscripts have been selected for review ranging in publication from 2007 to 2022, encompassing all continents of the globe and many diverse avenues of the forestry sector (Table 1, Figure 1).

3.1 Demographic Analysis / Demografska analiza

When evaluating the regions explored in the research articles selected, the largest sum of work took place in Asia/Oceania (11 of 36 - 31%), followed by Europe (8 of 36 - 22%), North

Table 1. Analysis of the literature used to identify trends and prospects regarding TEK in the forestry sector / **Tabela 1.** Analiza literature korišćene za identifikaciju trendova i izgleda u vezi sa TEK-om u sektoru šumarstva

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Deity Citadels: Sacred Sites of Bio-Cultural Resistance and Resilience in Bhutan (2019)	Elizabeth Allison	Asia/Oceania (Bhutan)	Holistic forest governance	This paper explores "deification" as a tool to promote forest protection and restoration in Nepal. Historical and ethnographic analyses show that the strengthening of Bhutanese Buddhist religious values with regards to forest ecosystems is crucial for promoting resilience in the face of globalized unsustainable development.	Religions (Journal) Allison, E. (2019). Deity Citadels: Sacred Sites of Bio-Cultural Resistance and Resilience in Bhutan. *Religions*, *10*(4), 268. https://doi.org/10.3390/rel10040268
Managing Visitor Experience and Appreciative Attitudes: Applying Traditional Ecological Knowledge to Guided Tours in Sarawak National Parks (2022)	Victor Luna Amin, Margaret Chan Kit Yok	Asia/Oceania (Malaysia)	Ecotourism	This research examines TEK as a tool for knowledge exchange through an ecotourism context in Sarawak National Parks, Malaysia. Documentation of ecotourism as a subset of TEK-based solutions remains highly underdeveloped in the research community. Results show a positive relationship between TEK knowledge exchange and interested/keen tourists following ecotourism participation.	Malaysia Conservation Conference (Conference Publication) Amin, V. L., & Chan Kit Yok, M. (Eds.). (2022). *Managing Visitor Experience and Appreciative Attitudes: Applying Traditional Ecological Knowledge to Guided Tours in Sarawak National Parks*. University of Teknologi MARA, Sarawak.
Tradition as asset or burden for transitions from forests as cropping systems to multifunctional forest landscapes: Sweden as a case study (2022)	Per Angelstam, Brita Asplund, Olaf Bastian, Engelmark, Mariia Fedoriak, Karen Grunewald, Pierre L. Ibisch, Per Lindvall, Michael Manton, Magnus Nilsson, Sten B. Nilsson, Peter Roberntz, Anton Shkaruba, Per Skoog, Ihor Soloviy, Miroslav Svoboda, Victor Teplyakov, Anders Tivell, Erik Westholm, Alina Zhuk, Leif Öster	Europe (Sweden, Russia, Germany, Czechia, Ukraine)	Silviculture	This paper explores a silviculture case study in Sweden through a historical lens, showing how different communities can interact in promoting more advanced forestry systems. Analysis shows that the Swedish forestry sector has gradually abandoned TEK for conservation measures.	Forest Ecology and Management (Journal) Angelstam, P., Asplund, B., Bastian, O., Engelmark, O., Федоряк, M., Grunewald, K., Ibisch, P. L., Lindvall, P., Manton, M., Nilsson, M., Nilsson, S., Roberntz, P., Shkaruba, A., Skoog, P., Soloviy, I., Svoboda, M., Teplyakov, V. K., Tivell, A., Westholm, E., . . . Öster, L. (2022). Tradition as asset or burden for transitions from forests as cropping systems to multifunctional forest landscapes: Sweden as a case study. *Forest Ecology and Management*, *505*, 119895. https://doi.org/10.1016/j.foreco.2021.119895

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Perception matters: an Indigenous perspective on climate change and its effects on forest-based livelihoods in the Amazon (2022)	Tina N. Bauer, Wil de Jonh, Verina Ingram	Latin America (Bolivia)	Climate change resilience	This paper explores the perceptions of the Indigenous Tacana people of Bolivia, examining how TEK can lead a critical climate change mitigation strategy. This research finds that Western science and TEK insights on weather trends complement one another. When documenting communal response to severe events (i.e. floods), strong bonding and social networking were valued amongst interviewed communities above other forms of capital.	Resilience Alliance (Research Network) Bauer, T., De Jong, W., & Ingram, V. (2022). Perception matters: an Indigenous perspective on climate change and its effects on forest-based livelihoods in the Amazon. *Ecology and Society*, 27(1). https://doi.org/10.5751/es-12837-270117
Managing forests for culturally significant plants in traditional Cherokee homelands: emerging platforms (2022)	M. Baumflek, T. Cabe, J. Schelhas, M. Dunlavey	North America (USA)	Holistic forest governance	This work examines the relationship between the Eastern Band of Cherokee Indians and the USDA Forest Service, showing how cultural recognition has been an asset in improving institutional relations. As a result of federal jurisdiction, many Indigenous forestry practices have been denied, complicated and delayed, contributing to a greater alienation between Indigenous and American leadership structures.	International Forestry Review (Journal) Baumflek, M., Cabe, T., Schelhas, J., & Dunlavey, M. (2022). Managing forests for culturally significant plants in traditional Cherokee homelands: emerging platforms. *International Forestry Review*, *24*(3), 298–314. https://doi.
Mapping risk factors to climate change impacts using traditional ecological knowledge to support adaptation planning with a Native American Tribe in Louisiana (2022)	Matthew B. Bethel, DeWitt H. Braud, Tara Lambeth, Donald S. Dardar, Patty Ferguson-Bohnee	North America (USA)	Climate change resilience	This study uses GIS technology to depict TEK of the Pointe-au-Chien Indian Tribe in Louisiana, USA, showing how well-documented management systems can be legitimized in wider policy networks. Sustainability factors identified include: 1. Spoil banks/speed bumps; 2. Culturally-relevant sites; 3. Cultural subsistence. Vulnerability factors include: 1. Oil canals; 2. Land loss; 3. Sea-level rise.	Journal of Environmental Management Bethel, M., Braud, D., Lambeth, T., Dardar, D. S., & Ferguson-Bohnee, P. (2022). Mapping risk factors to climate change impacts using traditional ecological knowledge to support adaptation planning with a Native American Tribe in Louisiana. *Journal of Environmental Management*, *301*, 113801. https://doi.org/10.1016/j.jenvman.2021.113801

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Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Congruence of local ecological knowledge (LEK)-based methods and line-transect surveys in estimating wildlife abundance in tropical forests (2021)	Franciany Braga-Pereira, Thais Q. Morcatty, Hani R. El Bizri, Aline S. Tavares, Carla Mere-Roncal, Carlos González-Crespo, Carolina Bertsch, Claudia Ramos Rodriquez, Claudio Bardales-Alvites, Eduardo M. von Mühlen, Galicia Fernanda Bernárdez-Rodríquez, Fernanda Pozzan Paim, Jhancy Segura Tamayo, João Valsecchi, Jonas Gonçalves, Leon Torres-Oyarce, Lísley Pereira Lemos, Marina A. R. de Mattos Vieira, Mark Bowler, Michael P. Gilmore, Natalia Carolina Angulo Perez, Rômulo Romeu da Nóbrega Alves, Carlos A. Peres, Pedro E. Pérez-Peña, Pedro Mayor	Latin America (Brazil, Peru)	Climate change resilience	This study analyzed both pre-existing data species (documenting 91 species) and TEK (via 291 interviews) regarding animal abundance in the context of Amazonian forestry. Findings show that TEK was highly effective at predicting population abundance based on a series of indicators (sociality, body size, forest type).	Methods in Ecology and Evolution (Journal) Braga-Pereira, F., Morcatty,T. Q., Bizri, H. R. E., Tavares, A. C. F. M. G., Mere-Roncal, C., González-Crespo, C., Bertsch, C., Rodríguez, C., Bardales-Alvites, C., Von Mühlen, E. M., Bernárdez-Rodríguez, G. F., Paim, F. P., Tamayo, J. S., Valsecchi, J., Gonçalves, J., Torres-Oyarce, L., Lemos, L. P., De Mattos Vieira, M. a. R., Bowler, M., . . . Mayor, P. (2021). Congruence of local ecological knowledge (LEK)-based methods and line-transect surveys in estimating wildlife abundance in tropical forests. *Methods in Ecology and Evolution*, *13*(3), 743–756. https://doi.org/10.1111/2041-210x.13773
Assessing traditional knowledge on forest uses to understand forest ecosystem dynamics (2013)	Matthias Bürgi, Urs Gimmi, Martin Stuber	Europe (Switzerland)	Broad forestry practices	This paper evaluates knowledge systems as a tool to identify critical forest uses in the context of the Swiss Alps. In the context of Switzerland, much of TEK forestry was abandoned during and after WWII; however, some practices persist in the rural and non-central regions of the country.	Forest Ecology and Management (Journal) Bürgi, M., Gimmi, U., & Stüber, M. (2013). Assessing traditional knowledge on forest uses to understand forest ecosystem dynamics. *Forest Ecology and Management*, *289*, 115–122. https://doi.org/10.1016/j.foreco.2012.10.012

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(Chapter 11) Stories of the Trees: Understanding Traditions and Transitions in the Katu Peoples' Perceptions of Forests in Central Vietnam (2022)	Hoan Thi Phan, Ha Van Le	Asia/Oceania (Vietnam)	Holistic forest governance	This research conducted a thorough anthropogenic study of the Katu people in Vietnam, showing how their cultural reverence of forest ecosystems can form a social resistance to degradation. Increased use of forest land for animal husbandry and commercial production was shown to have backfired, reducing economic self-reliance and increasing dependence on external financial flows. While the mention of "Belief Forests" exists in Vietnamese laws, little specific information exists regarding their legitimacy or protection.	Sacred Forests of Asia: Spiritual Ecology and the Politics of Nature Conservation (Book) Århem, N. (2022). The Katu Spirit Landscape Forests, Ecology, and Cosmology in the Central Annamites. In: Coggins, C., Chen, B. (Ed.), *Sacred Forests of Asia: Spiritual Ecology and the Politics of Nature Conservation*, Routledge, Oxfordshire: 217-230.
Restoration of selective beech coppices: A case study in the Apennines (Italy) (2007)	Matteo Coppini, Luigi Hermanin	Europe (Italy)	Silviculture	This paper documents the beech coppices of Italy as a case study, showing how traditional silvicultural techniques were vital in restoration efforts. Through performing traditional silvicultural coppice techniques on abandoned sites in the central Italy, this study finds that increased forest biomass potential could enhance Italy's wood and natural energy sectors.	Forest Ecology and Management (Journal) Coppini, M., & Hermanin, L. (2007). Restoration of selective beech coppices: A case study in the Apennines (Italy). *Forest Ecology and Management*, *249*(1–2), 18–27. https://doi.org/10.1016/j.foreco.2007.04.035
Implementing sustainable forest management in Ukraine's Carpathian Mountains: The role of traditional village systems (2007)	Marine Elbakidze, Per Angelstam	Europe (Ukraine)	Holistic forest governance	This piece documents the village cultures of the Boiko people in Western Ukraine, showing how rural lifestyles and values are crucial for sustainable forestry. As a result of early forestry intensification in the early-mid 20th century, many traditional village systems were destroyed in Western Ukraine, thus damaging TEK in this sector. Restoring TEK in Western Ukraine requires a bottom-up forestry governance approach, utilizing domestic and external tools to create economic opportunities in rural forested regions.	Forest Ecology and Management (Journal) Elbakidze, M., & Angelstam, P. (2007). Implementing sustainable forest management in Ukraine's Carpathian Mountains: the role of traditional village systems. *Forest ecology and management* 249(1-2): 28-38.

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When the seeds sprout, the hornbills hatch: understanding the traditional ecological knowledge of the Ibans of Brunei Darussalam on hornbills (2019)	F. Merlin Franco, Misa Juliana Minggu	Asia/Oceania (Brunei Darussalam)	Biodiversity tracking	This research documents the TEK observations and practices relating to hornbills in relation to forestry in Brunei Darussalam. TEK loss is being driven by many factors, five of which have been identified by elder participants: 1. Urban drift; 2. Abandonment of traditional hunting; 3. The shift in occupational preference to salaried jobs; 4. Formal education; 5. Lack of incentives to acquire TEK.	Journal of Ethnobiology and Ethnomedicine (Journal) Franco, F. M., & Minggu, M. J. (2019). When the seeds sprout, the hornbills hatch: understanding the traditional ecological knowledge of the Ibans of Brunei Darussalam on hornbills. *Journal of Ethnobiology and Ethnomedicine*, *15*(1). https://doi.org/10.1186/s13002-019-0325-0
Agricultural cooperatives contributing to the alleviation of rural poverty. The case of Konjic (Bosnia and Herzegovina) (2021)	Oriana Gava, Zahra Ardakani, Adela Delalić, Nour Azzi, Fabio Bartolini	Europe (Bosnia & Herzegovina)	Agroforestry	This study examined poverty indices in Bosnia-Herzegovina, interviewing rural farmers to extract their knowledge of traditional agriculture. The results conclude that farmers must have greater access to local and export markets to allow for small-scale development and knowledge exchange can occur.	Journal of Rural Studies (Journal) Gava, O., Ardakani, Z., Delalić, A., Azzi, N., & Bartolini, F. (2021). Agricultural cooperatives contributing to the alleviation of rural poverty. The case of Konjic (Bosnia and Herzegovina). *Journal of Rural Studies*, *82*, 328–339. https://doi.org/10.1016/j.jrurstud.2021.01.034
Beekeeping promotes the traditional home-garden conservation in Ethiopia (2021)	Tolera Kumsa, Tura Bareke, Admasu Addi, Kasim Roba	Africa (Ethiopia)	Agroforestry	This study conducted surveys from the central & western Ethiopia, evaluating TEK perceptions amongst agro foresters in the pollination sector. The results show that beekeepers who proximally integrate shrubbery, forestry and nectar-rich meadows with their hives yield greater honey (obviously) but also enhance the reproductive capacity and ecosystem health of these vegetative communities.	Journal of Agriculture and Environment for International Development (Journal) Kumsa, T., Bareke, T., Addi, A., & Roba, K. (2021). Beekeeping promotes the traditional home-garden conservation in Ethiopia. *Journal of Agriculture and Environment for International Development*, *115*(2), 23–37. https://doi.org/10.36253/jaeid-12084
Endogenous Berber Forest Management and the Functional Shaping of Rural Forests in Southern Morocco: Implications for Shared Forest Management Options (2011)	Didier Génin, Romain Simenel	Africa (Morocco)	Silviculture	This research explores mountainous terrain and argan tree ranges through three scales of forestry management: 1. Individual tree (cutting, etc.); 2. Tree stand level (determining type, etc.); 3. Landscape level (conscious grazing, etc.). In the cultures of many Berber communities, the "agdal" system regulates agro-sylvo-pastoral activities, encompassing spiritual, seasonal and territorial domains in terms of usage and governance.	Human Ecology (Journal) Génin, D., & Simenel, R. (2011). Endogenous berber forest management and the functional shaping of rural forests in Southern Morocco: Implications for shared forest management options. *Human Ecology*, *39*(3), 257–269. https://doi.org/10.1007/s10745-011-9390-2

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Traditional Ecological Knowledge Through Haudenosaunee Clanology (2022)	Valerie Gay Goodness	North America (Canada, USA)	Holistic forest governance	This dissertation explores clanology through the Haudenosaunee political system, exploring the ethnographic origins of the modern value systems of Haudenosaunee TEK. Findings show that TEK has had a profound influence on the managerial structure of Indigenous clanology throughout the eastern North America, as well as inspiring a cultural understanding of evolutionary ecology.	University of Buffalo (University Publication) Goodness, V. G. (2022). *Traditional Ecological Knowledge through Haudenosaunee Clanology*. [Doctoral dissertation, State University of New York at Buffalo].
Changing forest conservation and management paradigms: traditional ecological knowledge systems and sustainable forestry: Perspectives from Chile and India (2009)	Thora Martina Herrmann, Maria-Costanza Torri	Latin America, Asia/Oceania (Chile, India)	Holistic forest governance	This research explores the cultural significance of forestry to indigenous communities in India and Chile, showing how spiritual beliefs have inspired management practices in the forestry sector. Conflicts between traditional and government forces are observed in both contexts; because some trees need to be removed at higher rates, traditional ethno-foresters are often deemed to be exploitative, leading to poorer conservation outcomes.	International Journal of Sustainable Development & World Ecology (Journal) Herrmann, T. M., & Torri, M. (2009). Changing forest conservation and management paradigms: traditional ecological knowledge systems and sustainable forestry: Perspectives from Chile and India. *International Journal of Sustainable Development and World Ecology*, *16*(6), 392–403. https://doi.org/10.1080/13504500903346404
The right to burn: barriers and opportunities for Indigenous-led fire stewardship in Canada (2022)	Kira M. Hoffman, Amy Cardinal Christianson, Sarah Dickson-Hoyle, Kelsey Copes-Gerbitz, William Nikolakis, David A. Diabo, Robin McLeod, Herman J. Michell, Abdulah Al Mamun, Alex Zahara, Nicholas Mauro, Joe Gilchrist, Russell Myers Ross, Lori D. Daniels	North America (Canada)	Climate change resilience	Identifies cultural burnings as a critical aspect of TEK-led forestry management, with five barriers impacting this technique: 1. Perceptions, authority & jurisdiction; 2. Governance, laws & management; 3. Access, accreditation & training; 4. Liabilities & insurance; 5. Capacity & resources.	Facets (Journal) Hoffman, K. M., Christianson, A. C., Dickson-Hoyle, S., Copes-Gerbitz, K., Nikolakis, W., Diabo, D. A., McLeod, R. S., Michell, H., Mamun, A. A., Zahara, A., Mauro, N. A., Gilchrist, J., Ross, R. M., & Daniels, L. D. (2022). The right to burn: barriers and opportunities for Indigenous-led fire stewardship in Canada. *Facets*, *7*, 464–481. https://doi.org/10.1139/facets-2021-0062

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Cultural Keystone Species without Boundaries: A Case Study on Wild Woody Plants of Transhumant People around the Georgia-Turkey Border (Western Lesser Caucasus) (2021)	Ceren Kazancı, Soner Oruç, Marine Mosulishvili, Jeffrey Wall	Asia/Oceania (Turkey, Georgia)	Biodiversity tracking	This piece explores shared ethnobotanical knowledge between the communities in Turkey and Georgia, namely the identification of mutual Cultural Keystone Species. Both Turkey and Georgia are enhancing environmental strategies; the incorporation of Unified Cultural Keystone Species could be vital in developing sustainable bottom-up forestry.	Journal of Ethnobiology (Journal) Kazancı, C., Oruç, S., Mosulishvili, M., & Wall, J. C. (2021). Cultural Keystone Species without Boundaries: A Case Study on Wild Woody Plants of Transhumant People around the Georgia-Turkey Border (Western Lesser Caucasus). *Journal of Ethnobiology*, *41*(4), 447–464. https://doi.org/10.2993/0278-0771-41.4.447
Assessing local perceptions of deforestation, forest restoration, and the role of agroecology for agroecosystem restoration in northern Malawi (2022)	Daniel Kpienbaareh, Isaac Luginaah, Rachel Bezner Kerr, Jinfei Wang, Katja Poveda, Ingolf Steffan-Dewenter, Esther Lupafya, Laifolo Dakishoni	Africa (Malawi)	Agroforestry	This research examines TEK as a tool for knowledge exchange through an ecotourism context in Sarawak National Parks, Malaysia. Results show a positive relationship between TEK knowledge exchange and interested/keen tourists following ecotourism participation.	Land Degradation and Development (Journal) Kpienbaareh, D., Luginaah, I., Kerr, R. B., Wang, J., Poveda, K., Steffan-Dewenter, I., Lupafya, E., & Dakishoni, L. (2022). Assessing local perceptions of deforestation, forest restoration, and the role of agroecology for agroecosystem restoration in northern Malawi. *Land Degradation & Development*, *33*(7), 1088–1100. https://doi.org/10.1002/ldr.4238
How the loss of forest fauna undermines the achievement of the SDGs (2021)	Torsten Krause, Andrew Tilker	Global (North America, Latin America, Europe, Africa, Asia/Oceania)	Biodiversity tracking	This paper highlights the dangers of tropical defaunation, highlighting the importance of TEK in guiding effective defaunation metrics and recovery strategy. There are several suggestions provided to alleviate this problem, namely: 1. Interdisciplinary research; 2. Place-based conservation; 3. Recognizing TEK; 4. Curbing commercial wildlife trade; 5. Financing fauna in global climate portfolios; 6. Prioritizing local communities; 7. Comprehensive biodiversity measurements.	Ambio (Journal) Krause, T., & Tilker, A. (2021). How the loss of forest fauna undermines the achievement of the SDGs. *AMBIO: A Journal of the Human Environment*, *51*(1), 103–113. https://doi.org/10.1007/s13280-021-01547-5

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
(Chapter 5) Indigenous Biosecurity: Māori Responses to Kauri Dieback and Myrtle Rust in Aotearoa New Zealand (2018)	Simon J. Lambert, Amanda Black	Asia/Oceania (New Zealand)	Biodiversity tracking	This piece shows how Indigenous values have been incorporated into conventional forest biosecurity in New Zealand. The Maori communities of the Kauri districts responded by creating the KDP (a joint government agency) that would use TEK to craft personalized strategies to scale back the KD crisis. Despite promising results, many contemporary forestry managers were skeptical and difficult vis-a-vis the KDP.	The Human Dimensions of Forest and Tree Health (Book) Lambert, S., Waipara, N., Black, A., Mark-Shadbolt, M., & Wood, W. (2018). Indigenous biosecurity: Māori responses to kauri dieback and myrtle rust in Aotearoa New Zealand. In: Urquhart, J., Marzano, M., Potter, C. (Ed.), *The human dimensions of forest and tree health: Global perspectives*, Palgrave MacMillan, London: 109-137.
Indigenous Dayak Iban customary perspectives on sustainable forest management, West Kalimantan, Indonesia (2022)	Sandy Leo, Christ Margules, Jatna Supriatna	Asia/Oceania (Indonesia)	Holistic forest governance	This study documents the Iban community, which has been hugely successful in preserving high-value carbon sinks by establishing a self-sufficient feeding system that fosters a high degree of biodiversity. Carbon credits and ecotourism are identified as positive tools in which non-traditional economics could work alongside the Iban in promoting their forestry systems	Biodiversitas Journal of Biological Diversity (Journal) Leo, S., Supriatna, J., Mizuno, K., Margules, C. (2022). Indigenous Dayak Iban customary perspective on sustainable forest management, West Kalimantan, Indonesia. *Biodiversitas* 23: 424-435.
Regeneration Status and Role of Traditional Ecological Knowledge for Cloud Forest Ecosystem Restoration in Ecuador (2022)	Ana Mariscal, Mulualem Tigabu, Patrice Savadogo, Per Christer Odén	Latin America (Ecuador)	Holistic forest governance	Indigenous cultural and relative importance indices can accurately predict the most effective trees to plant (considering ratio, animal interaction and annual weather patterns). The rampant colonization of bamboo species and microhabitat conditions complicate old- growth forest regeneration. TEK and ecological science are synergistic, with relative importance indices/cultural value indices and informant surveys yielding near identical recommendations for future tree plantings to restore cloud forests.	Forests (Journal) Mariscal, A., Tigabu, M., Savadogo, P., & Odén, P. C. (2022). Regeneration Status and role of traditional ecological knowledge for cloud forest ecosystem restoration in Ecuador. *Forests*, *13*(1), 92. https://doi.org/10.3390/f13010092

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Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Hutsuls' perceptions of forests and uses of forest resource in Ukrainian and Romanian Bukovina (2022)	Giulia Mattalia, Nataliya Stryamets, Ágnes Bálazsi, G. Molnár, Adrian Gliga, A. Pieroni, Renata Sõukand, Victoria Reyes-García	Europe (Ukraine, Romania)	Holistic forest governance	Through a collection of perception-based qualitative interviews with Hutsul foresters in Ukraine and Romania, this study shows how the incidence of illegal logging combined with an increased agricultural intensification have greatly affected both nations' forestry industries. The neglect of TEK from these farmers is identified as a critical consequence of these incidents.	International Forestry Review (Journal) Mattalia, G., Stryamets, N., Balaszi, Á., Molnar, G., Gliga, A., Pieroni, A., Sõukand, R., & Reyes-García, V. (2022). Hutsuls' perceptions of forests and uses of forest resource in Ukrainian and Romanian Bukovina. *International Forestry Review*, *24*(3), 393–410. https://doi.
(Chapter 9) Gendered Values, Roles, and Challenges for Sustainable Provision of Forest-Based Ecosystem Services in Nepal (2022)	Jyoti Sedhain, Elson Ian Nyl Ebreo Galang	Asia/Oceania (Nepal)	Holistic forest governance	This study evaluates the gendered impacts of climate change on traditional forestry systems, showing how politico-economic forces impose pressure on women living in traditional communities in Nepal. Men disproportionately have frequent urban, non-forestry jobs while women tend to stay behind, making forestry often dominated by women in a globalized context. While Community Forestry User Groups succeed in empowering women in forestry, the management of mountain landscapes should also be prioritized to prevent overindulgence in deforestation practices	Human-Nature Interactions: Exploring Nature's Values Across Landscapes (Book) Sedhain, J., Galang, E. I. N. E. (2022). Gendered Values, Roles, and Challenges for Sustainable Provision of Forest-Based Ecosystem Services in Nepal. In: Misiune, I., Egarter Vigl, L., Depellegrin, D. (Ed.), *Human-Nature Interactions: Exploring Nature's Values Across Landscapes*, Springer, New York: 101-112.
Role of traditional ecological knowledge on field margin vegetation in sustainable development: A study in a rural-urban interface of Bengaluru (2022)	Sunil Nautiyal, Mrinalini Goswami	Asia/Oceania (India)	Agroforestry	This research explores interactions between Field Margin Vegetation (FMV) and TEK in India. As a result of lower biodiversity, agroecosystems are more vulnerable than natural environments, requiring greater resilience and strategy to maintain these spaces. The paper highlights how these ideologies can clash but also how they can work together in the South Asian context.	Trees, Forest and People (Journal) Nautiyal, S., Goswami, M. (2022). Role of traditional ecological knowledge on field margin vegetation in sustainable development: A study in a rural-urban interface of Bengaluru. *Trees, Forests and People*, 8.

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Examining abiotic and biotic factors influencing specimen black oaks (Quercus kelloggii) in northern California to reimplement traditional ecological knowledge and promote ecosystem resilience post-wildfire (2022)	Cory J. O'Gorman, Lisa Patrick Bentley, Clint McKay, Margaret Purser, Kylie M. Everly	North America (USA)	Climate change resilience	Through employing knowledge-based surveys of the land, the Pepperwood Native Advisory Council advised that a combination of prescribed burning and thinning was needed to increase the crown area of oak, a finding shared by the non-Indigenous research team. The article also emphasizes that TEK is not a static system, but rather subject to frequent innovation and adaptation.	Ecology and Society (Journal) O'Gorman, C. J., Bentley, L. P., McKay, C., Purser, M., & Everly, K. M. (2022). Examining abiotic and biotic factors influencing specimen black oaks (Quercus kelloggii) in northern California to reimplement traditional ecological knowledge and promote ecosystem resilience post-wildfire. *Ecology and Society*, *27*(2). https://doi.org/10.5751/es-13187-270219
Smallholder farmers' engagement with climate smart agriculture in Africa: role of local knowledge and upscaling (2022)	Ayorinde Ogunyiola, Maaz Gardezi, Sumit Vij	Africa (Kenya, Ethiopia, Uganda, Malawi, South Africa, Zimbabwe)	Agroforestry	Climate-smart agriculture (CSA) remains crucial for many African governments, yet adoption remains low among smallholder farmers. Part of this issue stems from the lack of TEK representation of CSA models.	Climate Policy (Journal) Ogunyiola, A., Gardezi, M., & Vij, S. (2022). Smallholder farmers' engagement with climate smart agriculture in Africa: role of local knowledge and upscaling. *Climate Policy*, *22*(4), 411–426. https://doi.org/10.1080/14693062.2021.2023451
Understanding Yurok traditional ecological knowledge and wildlife management (2021)	Seafha C. Ramos	North America (USA)	Holistic forest governance	This research aims to build a bridge between scientists and Indigenous leaders, showing how TEK knowledge can be transferred coherently through the case of the Yurok Tribe of California, USA. Participants note that genocidal acts from the US government have played a big role in dampening TEK in surveyed Indigenous communities; in addition, several participants felt little to no affinity with the term "TEK", stating that it is simply a way of life rather than an academically-categorized system.	The Journal of Wildlife Management (Journal) Ramos, S. C. (2021). Understanding Yurok traditional ecological knowledge and wildlife management. *The Journal of Wildlife Management*, *86*(1). https://doi.org/10.1002/jwmg.22140
Pala'wan Highlanders, their connectedness to the Forest About Agro-ecology as a perspective for the future of Palawan (2022)	Nicole Revel	Asia/Oceania (Philippines)	Holistic forest governance	This piece documents the personalized perception of rain-forest governance in Palawan, highlighting the values, belief systems and governance structures of the Pala'wan Highlanders. Findings indicate the importance of retaining an ecologically intact forest ecosystem to sustain Pala'wan forestry practices.	AghamTao Ugnayan Pang-Aghamatao (Research Network) Revel, N. (2022). Pala'wan Highlanders, their connectedness to the Forest About Agro-ecology as a perspective for the future of Palawan. *AghamTao*.

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continuation of Table 1 / nastavak Tabele 1

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Evaluating the efficacy of GIS maps as boundary objects: unpacking the limits and opportunities of Indigenous knowledge in forest and natural resource management (2021)	Ashley Shaw, Toddi Steelman, Ryan Bullock	North America (Canada)	Holistic forest governance	The particular case study explores the Beardy & Okemasis Cree Nation, collecting TEK regarding forestry governance over two years and developing a GIS map to accommodate Houde's six faces of TEK. The final product yielded varying levels of success between aligning boundary objects and TEK faces.	Journal of Cultural Geography (Journal) Shaw, A. M., Steelman, T. A., & Bullock, R. (2021). Evaluating the efficacy of GIS maps as boundary objects: unpacking the limits and opportunities of Indigenous knowledge in forest and natural resource management. *Journal of Cultural Geography*, *39*(1), 90–116. https://doi.org/10.1080/08873631.2021.2011683
Local traditional ecological knowledge about hay management practices in wetlands of the Biebrza Valley, Poland (2022)	Joanna Sucholas, Zsolt Molnár, Łukasz Łuczaj, Peter Poschlod	Europe (Poland)	Agroforestry	"Explores local farmers' knowledge and cultural practices of wetland management, showing how they form an integral component to both internal and external decision-making on the front of ecosystem services. Farming intensification in the 1960s caused the abandonment of TEK, with many traditions being lost; this study explores if any knowledge/practices remain. The study found that older generations had the most advanced knowledge of the wetlands, with biannual mowing strategies helping to ensure adequate livestock & grazing, as well as habitat restoration.	Journal of Ethnobiology and Ethnomedicine (Journal) Sucholas, J., Molnár, Z., Łuczaj, Ł., & Poschlod, P. (2022). Local traditional ecological knowledge about hay management practices in wetlands of the Biebrza Valley, Poland. *Journal of Ethnobiology and Ethnomedicine*, *18*(1). https://doi.org/10.1186/s13002-022-00509-9
Traditional Ecological Knowledge Informing Resource Management: Saxoul Conservation in Inner Mongolia, China (2010)	Ruifei Tang, Michael C. Gavin	Asia/Oceania (China, Mongolia)	Biodiversity tracking	This research shows how the Chinese government disregarded the Mongolian nomad community's knowledge, jeopardizing the vital saxaul tree of the Gobi desert region. Chinese government policies sought to close reserves and aerially seed, strategies proving to be ineffective and inconsiderate of the Mongolian TEK.	Society and Natural Resources (Journal) Tang, R., & Gavin, M. C. (2010). Traditional Ecological Knowledge Informing Resource Management: Saxoul Conservation in Inner Mongolia, China. *Society & Natural Resources*, *23*(3), 193–206. https://doi.org/10.1080/08941920903375503

Title	Author(s)	Region(s) Examined	Forestry Sector Discussed	Summary	Publication Source & Citation
Unleashing traditional ecological knowledge for biodiversity conservation and resilience to climate change in Rwanda (2021)	Nathan Kanuma Taremwa, Marie-Christine Gasingirwa, Donat Nsabimana	Africa (Rwanda)	Broad forestry practices	This research investigated the particular methods of TEK employed by communities in the surroundings of the Nyungwe National Park. Forest conservation and controlled burnings were found to be the most important techniques among interviewed foresters.	African Journal of Science, Technology, Innovation and Development (Journal) Taremwa, N. K., Gasingirwa, M., & Nsabimana, D. (2021). Unleashing traditional ecological knowledge for biodiversity conservation and resilience to climate change in Rwanda. *African Journal of Science, Technology, Innovation and Development*, *14*(1), 204–215. https://doi.org/10.1080/20421338.2020.1821948
The forest is clothing for the ancestors: A rapid cultural assessment tool for forest landscape restoration policy processes (2022)	Robert Wild, Gretchen Walters	Africa (Malawi, Mozambique)	Holistic forest governance	This research developed a ten-question ROAM (Restoration Opportunities and Assessment Methodology) tool to evaluate the state of a country's/region's traditional forestry knowledge. Findings show that in many colonized countries, infrastructural disruptions coupled with rapid globalization have weakened the impetus to prioritize pre-existing knowledge structures in the forestry industry.	Forest Ecology and Management (Journal) Wild, R., & Walters, G. (2022). The forest is clothing for the ancestors: A rapid cultural assessment tool for forest landscape restoration policy processes. *Forest Ecology and Management*, *504*, 119825. https://doi.org/10.1016/j.foreco.2021.119825

America (7 of 36 - 19%), Africa (5 of 36 - 14%), Latin America (3 of 36 - 8%) and Global (2 of 36 - 6%). When assessing the nature of research in the selected pieces, journal publications form the majority (30 of 36 - 83%), followed by book chapters (3 of 36 - 8%), academic publications (2 of 36 - 6%) and conference publications (1of 36 - 3%). Primary research is more common in the selected literature (29 of 36 - 81%) than that of secondary research (7 of 36 - 19%). When examining the forestry sectors explored in each research, holistic forest governance forms the largest portion (13 of 36 - 36%), followed by agroforestry (6 of 36 - 17%), biodiversity tracking (5 of 36 - 14%), climate change resilience (5 of 36 - 14%), sylviculture (3 of 36 - 8%), broad forestry usage (8%) and ecotourism (1 of 36 - 3%).

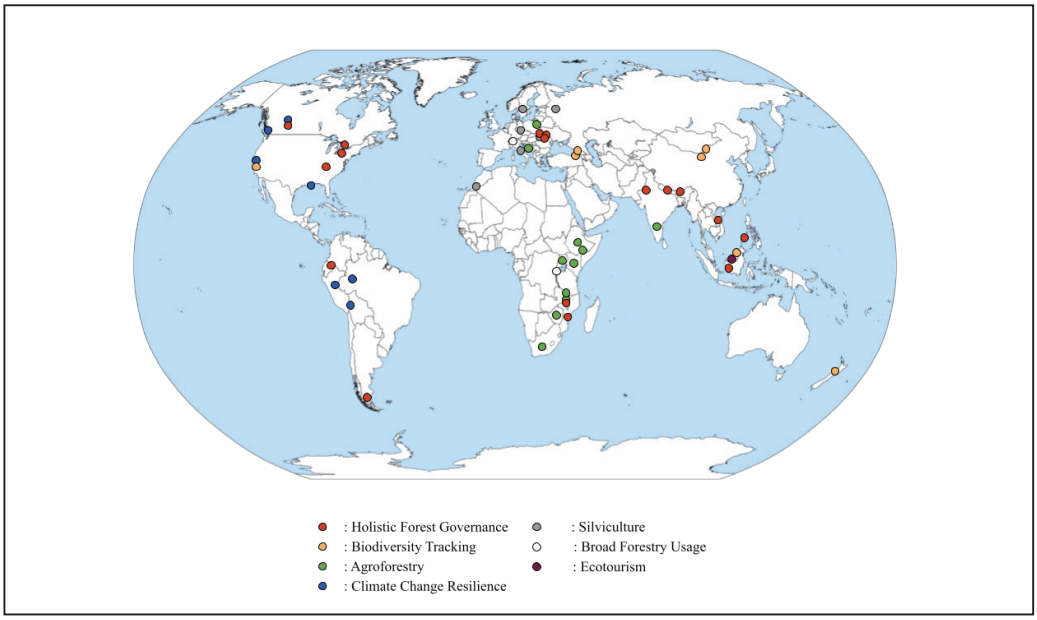

Figure 1. Global distribution of articles selected for research synthesis. Color-coded dots correspond to research areas explored in the literature / **Slika 1.** Globalna distribucija članaka odabranih za sintezu istraživanja. Tačke označene bojama odgovaraju istraživačkim oblastima koje su istražene u literaturi.

3.2 Literature Evaluation / Evaluacija literature

The first section of the synthesis evaluates the particular ways in which TEK influences aspects of development, namely in the social, political and economic spheres. When examining the impact of TEK on social development, nearly all works (34 of 36 - 94%) directly mention the benefits of TEK on the front of communal and interpersonal development. The two remaining pieces do not touch on the influence of TEK on social development (2 of 36 - 6%), with none directly mentioning the negative effects of TEK on social development. Political development indicates greater variability, although the majority of research articles indicate a positive relationship between the promotion of TEK and healthier leadership. A smaller portion of articles indicate mixed results regarding the relationship with political development (7 of 36 - 19%), and six do not mention the topic of politics whatsoever (6 of 36 - 17%). Most of the articles indicate a correlation between economic development and TEK (30 of 36 - 83%), although there are some articles indicating mixed results (3 of 36 - 8%), with some making no mention of this relationship (3 of 36 - 8%).

The second section of the synthesis statement explores the concept of neglecting TEK, which often stems from governmental as well as scientific leadership circles. Results from the selected research indicate that TEK is often neglected by non-traditional communities (26 of 36 - 72%), with several not mentioning this point (5 of 36 -14%). A small portion of articles directly contradicts the claim that TEK is neglected, instead showing current successful relationships in the particular regions examined (3 of 36 - 8%). An even smaller selection of articles provides mixed results with regard to TEK being neglected (2 of 36 - 6%).

4. DISCUSSION / DISKUSIJA

The selection of articles on a global basis makes this a unique study on the front of TEK, in that it includes traditional forestry from every continent. While individual forestry practices and values can vary greatly between different cultural spheres, the common themes and trends observed in the selected literature demonstrate how small-scale, communal knowledge systems can create nature-based approaches to forest governance. The implications of these enhanced governance tools are widespread, ranging from improved arboreal regeneration (Coppini & Hermanin, 2007; Hoffman et al., 2022) to expanding agroforestry programs (Kpienbaareh et al., 2022; Nautiyal & Goswami, 2022; Taremwa et al., 2022) to stronger resilience in the face of climate change (Bauer et al., 2022; Bethel et al., 2022).

4.1 Social, Political and Economic Development / Društveni, politički i ekonomski razvoj

When examining the role of development in each context outlined in the introduction, specific themes in traditional forestry governance can be more clearly identified. The overwhelming evidence of social benefit from functional TEK in forestry indicates the unique and critical bonds that human communities share with forest ecosystems. The diversity of forestry sectors covered in this report further demonstrates this fact, showing that nature-based solutions to managing forests provide sociological, communal and spiritual benefits. Allison (2019) demonstrates this trend in the context of Bhutan, whereby religiously rooted forestry governance in local communities forms a source of arbitration between forestry officials at all tiers throughout the country. This trend is especially pronounced in the North American context (Baumflek et al., 2022; Goodness, 2022; Hoffman et al., 2022; Shaw et al., 2021) whereby cosmological understandings of holistic forestry have informed social communalism and resilience in pre- and post-colonial eras. Political development is a more complicated story, however. In the articles that affirm a positive relationship between political development and TEK in a forestry context, many case studies explore new developments between governmental, scientific and traditional leaders in the forestry sector (Franco & Minggu, 2019; Taremwa et al., 2022).

With greater recognition and demand for intercultural cooperation on the front of sustainability, especially given the widespread ratification of liberal international treaties related to forestry, many governments have a newfound impetus to develop healthy relations with traditional communities. However, there is a sizable minority of articles that demonstrate mixed results, showing that political development does not necessarily share a symbiotic relationship with the promotion of TEK in the context of forestry (Genin & Simenel, 2011; Herrmann & Torri, 2009; Kpienbaareh et al., 2022; Leo et al., 2022). There are several trajectories contributing to mixed results, the most common one being differing economic values. In many corrupt, impoverished and developmentally stagnant environments, the drive to expand industrial practices in forest ecosystems is often very strong (Genin & Sim-

enel, 2011). When traditional communities' values regarding forestry governance demand the preservation and minimal interference with these ecosystems, values clash, creating a developmental liability for non-traditional leadership (Tang & Gavin, 2010). This problem is particularly pronounced in settler-colonial contexts (Baumflek et al., 2022; Bethel et al., 2022; Goodness, 2022; Lambert et al., 2018; O'Gorman et al., 2022), whereby the sudden and rapid imposition of larger governmental administrations drastically overpower the ecological agency of local Indigenous communities. As economics and politics are inseparable in a developmental context, a similar dilemma presents itself when exploring the relationship between economic development and the promotion of TEK in forestry. Economies lacking a strong potential for infrastructural innovation often antagonize TEK in the forestry sector, arguing that non-invasive forest techniques "waste" the natural capital potential abundant in forest ecosystems (Coppini & Hermanin, 2007). However, many authors point out the irony of this mindset, with the neglect of TEK often leading to inefficient projects with a host of practical liabilities, stemming from the rejection of nature-based solutions (Allison, 2019; Baumflek et al., 2022; Elbakidze & Angelstam, 2007; Goodness, 2022).

4.2 Neglect of TEK by Mainstream Forestry Actors / Zanemarivanje TEK-a od strane glavnih šumarskih aktera

The neglect of TEK has been and continues to be a topic of concern for development and social relations in many sectors, forestry being no exception. Approximately three in four articles directly note the ignorance many mainstream forestry and governmental circles have for TEK-based practices, creating an ideological rift in the forestry sector. Bethel et. (2022) al note that the exclusion of TEK in forestry research has strengthened the de-legitimization of local knowledge systems, often creating ambivalence and even contempt amongst large-scale leadership responsible for forestry innovation. However, there are some articles in which TEK has garnered greater support for non-traditional authorities. There are many domains in which this trend has materialized, although the rise in innovative sustainability plays a large role in the wider conversation (Angelstam et al., 2022; Leo et al., 2022; Mattalia et al., 2022). Through creating an environment in which improved social relations are a core goal of mainstream governmental authorities, working alongside traditional communities has proven successful in some cases (Amin & Kit Yok, 2022; Bauer et al., 2022). This trend occurs broadly through two trajectories. The first case comes from governments with lower levels of corruption, coupled with a strong and adamant traditional forestry sector (Allison, 2019). The greater propensity to ratify treaties protecting traditional forestry has allowed these regions to better accommodate and work alongside different scales of forest management (Krause & Tilker, 2022; Lambert et al., 2018;). The second case entails highly specific forestry sectors which provide a clear benefit to mainstream leadership, such as aesthetic-based industries (Amin & Kit Yok, 2022). Ecotourism is the best example of this trend, whereby the promotion of TEK has increased tourist revenue, thus providing a governmental incentive to promote TEK in the industry (Amin & Kit Yok, 2022). Mixed results on the front of TEK neglect are observed in two instances, originating from conflicting values within governmental institutions as well as from foresters themselves. In the case of Nepal, Seghain & Galang et al. (2022) note that the government has been proactive in supporting the efforts of women leading local forestry management endeavors, even creating specialized programs to support this instance of TEK. However, the drive to pursue deforestation practices related to industrial development, such as coal extraction, has also pre-occupied the Nepalese government's attention, leading to indirect consequences for female foresters in the nation. In Wild & Walter's (2022) research, the drive for moder-

nity amongst many foresters in the impoverished regions of Malawi and Mozambique has caused the neglect of TEK, even in communities with deep-rooted connections to holistic forest governance.

4.3 Sustainability and Social Consequences of Neglecting TEK / Održivost i društvene posljedice zanemarivanja TEK-a

Connecting a direct link between weakened forestry sustainability and TEK neglect generates a host of results. This variability stems from the broad nature of research on this topic, with many works indicating variable relationships between these two variables. That being said, the majority of articles indicate that the neglect of TEK from both governmental and scientific leaders in the forestry sector contributes to a host of negative consequences for the forestry sector (Århem, 2022; Ogunyiol et al., 2022; Tang & Gavin, 2010). One avenue stems from social division, whereby the alienation of communities from their traditional practices creates a rift in the ecological values of the region studied (Genin & Simenel, 2011; Kpienbaareh et al., 2022; Wild & Walters, 2022). Another avenue stems from poor sustainability as a result of TEK neglect, a consequence that presents itself in many unique ways. One avenue of poor sustainability stems from the high demand for deforestation, neglecting these ecosystems in favor of other industrial pursuits, such as charcoal (Kpeinbaareh et al., 2022), mass-logging (Mattlia et al., 2022) and urban infrastructure (Århem, 2022; Kazancı et al., 2021). Another way in which TEK neglect harms sustainability is scientific ignorance. Because many forestry practices rooted in TEK have been well-tested over multiple generations, awareness of unique biophysical processes is often well-documented. When governments and forestry leaders impose their visions of forest preservation, ignorance of these particular biophysical interactions can cause harm to forest ecosystems in the long run (Mariscal et al., 2022; Tang & Gavin, 2010).

4.4 Limitations and Insights / Ograničenja i uvidi

As with all research works, this paper is not without its limitations. In exploring such a broad selection of articles based on geography and forestry context, finding intersectoral trends is difficult. To better understand the current state of TEK in forestry in a diversified setting, a deeper analysis of papers based on the region and forestry sector discussed would be beneficial. Through conducting more focused synthesis reports on this topic, researchers and actors in forestry could gain a better view of which particular barriers are prevalent in which industries of the forestry sector. In addition, the particular issues analyzed in this paper are surface-level, evaluating the state of TEK in modern forestry as a whole. However, the specific issues faced by local and Indigenous people are diverse, multi-faceted and often intersectional. The findings of this paper strengthen the impetus to conduct both primary and secondary research in more focused contexts of forestry, identifying the specific policies, actions and cultural shifts required to create a more sustainable and equitable forestry sector.

In the post-COVID-19 era, communication within and between communities has been made easier than ever before. Many communication barriers have been gradually resolved through the rapid innovation of telecommunications technology, and both leaders and researchers have the opportunity to utilize TEK in forestry. While Houde's "six faces of TEK" do an excellent job of encompassing the core tenets of traditional environmental governance, each community will have its own specialized set of principles used to guide forest usage. Through utilizing GIS technology, as evidenced by Shaw et al (2021), the quantification of certain keystone species, resource values and micro-habitats can be developed and compartmentalized by key actors in the forestry sector. Helping strengthen ties within and between local communities would also help maintain economic diversity on a geographic level, especially in

regions undergoing rapid industrial development. As noted by many researchers highlighted in this report, the widespread exodus of traditional foresters has been driven by socio-economic isolation caused by the ignorance of TEK-centered forestry practices (Angelstam et al., 2022; Bürgi et al., 2013; Elbakidze & Angelstam, 2007). If leaders and researchers help create these connections, technological innovation could coincide with the preservation of TEK, thus creating a greater impetus for traditional foresters to continue strengthening their practices. This point is especially relevant in countries housing Indigenous population, whereby the calls for reconciliation are growing stronger, both on domestic and international levels (Bethel et al., 2022; Ramos, 2022). Reconnection to the land has been noted as one of the most important goals of Indigenous communities, and achieving this goal could be made possible through integrating advanced technologies between cultural spheres.

5. CONCLUSION / ZAKLJUČAK

As seen in case studies across the globe, TEK has been playing a crucial role in maintaining cultural sustainability frameworks. However, the continued dominance of macro-level scientific and governmental leadership has contributed to the widespread neglect and ignorance of these knowledge systems. This process is both problematic and unnecessary, with the consequences ranging from social alienation to forest degradation. Utilizing knowledge systems that have been well tested and become embedded in the cultural fabric of a region is worth preserving and utilizing in the creation of sustainable forestry, and there are many ways for actors in the industry to assist with this process.

As the climate crisis ensues, sustainability in the forestry sector is no longer a benefit; it is a requirement. Ensuring that forestry industries adopt sound practices that respect the present and future requirements of forest ecosystems is necessary for security and stability within the sector. Utilizing local knowledge to create these practices would be an asset to any sustainability initiative, as many TEK-based forestry techniques have been perfected to accommodate the natural world over multiple centuries. This particular issue could also assist greatly with reconciliation and socio-economic integration efforts, as local communities would become leaders at the forefront of sustainability. Providing a space to not only listen to but also work alongside often-neglected communities is crucial for any concrete socio-political change, and TEK provides the forestry sector with a perfect opportunity. Through utilizing telecommunications, an abundance of research and pre-existing programs, political and scientific leaders can create a new chapter in the history of forestry all over the world, ensuring that the well-tested sustainable practices of the past can become integrated with the rapidly evolving markets and technologies of today.

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Sažetak

Koncept tradicionalnog ekološkog znanja (TEK) kao filozofije za korišćenje resursa je sve popularniji koncept u međunarodnom razvoju, iako ostaje uglavnom pogrešno shvaćen. U mnogim prethodnim školama mišljenja, TEK je često doživljavan kao skup specifičnih praksi popularnih među autohtonim zajednicama u vezi sa upravljanjem resursima. U savremenim državnim i naučnim okruženjima, ovi koncepti se odbacuju kao „primitivni", nesposobni da obezbijede inovacije na planu korišćenja resursa i društveno-ekonomske situacije. Međutim, kako se globalizovano istraživanje i razvoj sve više interesuju za ovaj koncept, koncept tradicije u konceptu resursa dobija mnogo holističkiji značaj. U sektoru šumarstva, TEK kao globalni fenomen je neistražena tema. Cilj ovog istraživanja je popuniti ovu prazninu u znanju kroz sintezu literature koja istražuje TEK u kontekstu šumarstva. Kao prvo, studija istražuje kako TEK utiče na društvene, ekonomske i političke dimenzije savremenog šumarstva, a kao drugo, kako TEK percipiraju vladine i naučne zajednice, ispitujući uticaje ovog odnosa u savremenom kontekstu.

Za analizu je odabrano ukupno trideset šest istraživačkih radova objavljenih u periodu od 2007. do 2022. godine, od kojih su većina recenzirani članci u časopisima (30), kao i poglavlja u knjigama (3), akademske publikacije (2) i jedan rad sa konferencije. Specifični detalji u vezi sa ovim člancima navedeni su u Tabeli 1, uključujući: 1. Autor(e); 2. Ispitani region(i) sveta; 3. Razgovarano o sektoru šumarstva; 4. Ključni nalazi; 5. Izvor publikacije. Da bi se demonstrirala globalna širina ove pretrage literature, globalna distribucija identifikovanih radova prikazana je na Slici 2., koja označava konkretna istraživačka mjesta svih članaka na mapi svijeta. Svi recenzirani članci su morali da stave poseban fokus na lokalizovanu zajednicu ili etničku grupu koja se bavi šumarstvom, pri čemu se autori direktno pozivaju na tradicionalne kvalitete navedenih šumarskih praksi. Da bi se posebno analizirali odnosi TEK-a sa netradicionalnim izvorima upravljanja šumama (tj. državnim i naučnim upravljanjem), od pregledanih članaka se zahtijevalo da se napravi posebna distinkcija između ova dva izvora upravljanja.

Ogromna većina članaka ukazuje da TEK ima pozitivan efekat na polju društvenog razvoja. Mnogi od članaka navode ukrštanje kulturnih, vjerskih i duhovnih vrijednosti kao manifestaciju TEK-a u sektoru šumarstva, koje imaju i nastavljaju da pružaju zajednicama snažnu socio-ekonomsku osnovu (Allison, 2019; Baumflek et al., 2022; Goodness, 2022; Hoffman et al., 2022; Shav et al., 2021). Interakcije između TEK-a i političkog razvoja su raznovrsnije u literaturi, uglavnom vođene različitim stepenom hijerarhije u ispitivanim društvima. U nekim kontekstima, netradicionalne vlasti imaju veoma snažan uticaj na upravljanje šumama, pri čemu tradicionalne zajednice predstavljaju prijetnju širim socio-ekonomskim interesima (Genin & Simenel, 2011; Herrmann & Torri, 2009; Kpienbaareh et al., 2022). Međutim, drugi članci ukazuju na sinergijski odnos između političkog razvoja i TEK-a, otkrivajući da netradicionalne vlade mogu imati koristi od diverzifikacije svojih pristupa i aktera koji se koriste za izvršavanje planova upravljanja šumama (Frango & Minggu, 2019; Taremva et al., 2022). Slično političkom razvoju, ekonomski razvoj i TEK imaju složen odnos koji je pod velikim uticajem analiziranog konteksta. U člancima koji pronalaze pozitivnu vezu između ove dvije varijable, sektor šumarstva se u velikoj mjeri razvio i diverzifikovao, čime je TEK postao socio-ekonomska prednost (Amin & Kit Iok, 2022; Krause & Tilker, 2022). Međutim, mnoge studije daju mješovite rezultate između ovih varijabli zbog veoma rigidnih percepcija upravljanja šumama, stvarajući ekonomski rascjep između uočenih tradicionalnih i netradicionalnih dijelova društva (Allison, 2019; Coppini & Hermanin, 2007; Elbakidze & Angelstam, 2007) . Skoro svi radovi identifikuju TEK kao zanemaren od strane netradicionalnog rukovodstva šumarstva, sa mnogim identifikovanim specifičnim posljedicama kao rezultatom. Socio-ekonomska otuđenost TEK-a često ostavlja ruralne zajednice izolovanim od urbanih, što rezultira snažnom podjelom siromaštva i potencijalom za eksploataciju (Århem, 2022; Oguniiol et al., 2022; Tang & Gavin, 2010).

Na osnovu trendova u literaturi, utvrđeno je nekoliko važnih zaključaka iz ovog istraživanja. TEK ostaje neodvojiva komponenta međunarodnog razvoja, posebno u sektoru šumarstva. Sva društva imaju generacijski nasleđene tehnike na polju upravljanja resursima. Kada vlade i naučne zajednice ignorišu stvarnu vrednost koju ove prakse imaju u savremenom kontekstu, društva su isključena, a vrijedno znanje se rasipa. Buduća istraživanja treba usmjeriti prema istraživanju mehanizama specifičnih za kontekst koji dovodi do zanemarivanja TEK-a u glavnim šumarskim krugovima. Pored toga, razumevanje inovativnih načina na koje se TEK može inkorporirati u savremeno šumarstvo je ključno za rješavanje mnogih pitanja identifikovanih u ovoj sintezi istraživanja.

Ključne riječi: okviri politike, prava urođenika, sinteza literature, socijalna ekonomija, tradicionalna ekološka znanja (TEK), upravljanje šumama