

Traditional Ecological Knowledge in Europe: Status Quo and Insights for the Environmental Policy Agenda¹

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Over the last two decades, traditional ecological knowledge (TEK) has gained increasing attention as a source of information for environmental science, policy, and management. TEK is defined as 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. [1] Although TEK is different from scientific knowledge, both bodies of knowledge are believed to be largely complementary, having great potential to enrich one another in informing decision-making processes and improving understanding of ecosystems and their dynamics. [2,3] TEK can provide insights for the management of species, habitats, ecosystem services, protected areas, and human-shaped landscapes in general. Well-known examples of TEK guiding resource management include the watershed management of salmon rivers by the Amerindians of the Pacific Northwest, [4] biodiversity enhancement through creation of forest islands by the Kayapo of Brazil, [5] and the conservation of ancient human-influenced natural environments, such as the Satoyama landscapes in Japan. [6] Furthermore, it has been argued that implementing TEK may increase the capacity of social-ecological systems to deal with crises, cope with disturbances, maintain long-term resilience, and thus respond to global environmental change, [7-10] while also fostering biodiversity and human wellbeing in a harmonious way. [11,12] Theoretical insights and empirical findings addressing the linkages between TEK and global environmental change suggest that despite the worldwide trend of TEK erosion, there is also a process of hybridization, where traditional knowledge, practices, and beliefs are merged with novel forms of knowledge and technologies to create new knowledge systems that seem to increase the resilience of social-ecological systems. [13]

Traditional Ecological Knowledge History and Definition

TEK can be seen as part of the adaptive strategies developed by human societies to dwell and survive in a variety of environments. [14] Although knowledge, practices, and beliefs embedded in TEK systems are as ancient as the practices of hunting and gathering, [15] the use of the term in scientific research fields (e.g., ethnobotany) dates back only to the 1960s. Furthermore, it was not until the 1980s that the term TEK came into widespread use within disciplines such as ethnomedicine, botany, linguistics, and archaeology [16,17] and was only incorporated into social-ecological resilience theory in the 1990s.

During the last 20 years, disciplines such as conservation biology, forestry, ecology, and landscape management have slowly started to incorporate insights from TEK. [18] The natural and social science streams involved in TEK research are now converging through the notion of biocultural diversity, which suggests that loss of biological diversity and loss of cultural diversity are interrelated processes. [19]

Researchers have proposed many definitions of TEK and have often used words such as “local,” “indigenous,” and “traditional” as synonyms when describing people’s knowledge of their local environments. [20] Although there is no consensual description of the term, most researchers have adopted the definition of TEK as “a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relation of living beings (including humans) with one another and the environment.” [21]

However, in line with T. Ingold’s suggestion, the classical definition of TEK, where information is possessed by generations and handed down from the past, may not be the only

transmission path for TEK. [22] Rather, local perception of traditional knowledge is indistinguishable from daily life activity and is thus perpetually generated. Moreover, local people may dynamically combine traditional and orally transmitted knowledge with popular or even scientific, exogenous ecological knowledge. [23] This allows reflection on what ways in literate societies, like most of the European ones, the transmission of TEK through written texts and, more recently, other media containing local as well nonlocal knowledge can have immediate and prolonged effects. [24] As pointed out by E. Gómez-Baggethun and V. Reyes-García, the fact that a specific unit of knowledge is lost or kept by a society is not as important as whether the society retains the ability to generate, transform, transmit, and apply knowledge. [25] In that regard, the concept of TEK should be understood as a collaborative concept inviting diverse populations to continually learn from one another about how each approaches “knowledge” and how these approaches can be blended to better steward natural resources. [26]

Therefore, we suggest a revision of the understanding of TEK within the European context, taking into consideration the peculiarities of generation, transmittance, and the consequences for building a collaborative TEK concept that could enrich environmental governance processes such as the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Contribution of Traditional Ecological Knowledge to Policy

As TEK holds the potential to contribute to sustainable ecosystem management, it has received increasing attention in the political arena. Although TEK had previously been considered to represent a rudimentary form of thinking, during the 1990s it was internationally recognized by the Convention on Biological Diversity (CBD) [27] and in 2003 it was proclaimed by UNESCO worthy of protection through the Convention for the Safeguarding of Intangible Cultural cultural landscapes shaped by TEK-driven resource use have also been receiving increasing attention. For example, TEK was recently included in the CBD Conference of the Parties (COP10), under the heading of “Socio-Ecological Production Landscapes,” understood as “landscapes that people have developed and maintained sustainably over long periods of time.” [29]

Moreover, the IPBES has just recognized the importance of TEK, intending “to develop an understanding of how to effectively integrate local and traditional knowledge and to develop a communications strategy for the platform.” [30] Recording local and traditional knowledge of biodiversity has been acknowledged as a prerequisite for fair representation and relevance of IPBES to all spheres of society. [31] However, comprehensive guidelines on the integration of TEK to inform policy processes have not yet been developed.

Overall, the IPBES process could move TEK forward on the European environmental policy agenda by promoting broader consideration of the role of rural communities and associated knowledge in achieving sustainability targets. In this way it may, for instance, trigger revision of the Common Agriculture Policy (CAP), the Natura 2000 network of protected areas, the European Union (EU) Biodiversity Strategy to 2020, and other EU-wide established policies. However, a critical precondition for TEK to be useful in the policy arena is that conditions for the regeneration of TEK are maintained and that sufficient levels of sovereignty over land, ecological means of production, technology, and livelihood-related knowledge systems are held. Understanding the importance of the fact that local people remain close to the

production of knowledge [32] can contribute to the debate on the inclusion of lay users of natural resources in knowledge generation, which appears to have become a central issue for environmental sustainability projects. [33] F. Berkes argues that sustainability research should involve “processes of co-production” of knowledge in which stakeholders interact with experts in the process of defining the important research questions and the relevant evidences for answering these, especially in situations of high uncertainty and complexity. [34] In that sense, the integration of TEK in policy processes will make natural resources governance more democratic and participatory.

Purpose of This Study

While indigenous peoples living in threatened ecosystems in developing countries, particularly in Latin America, have attracted much attention for TEK research, 35 researchers have concluded that other rural people (e.g., farmers, fishers) are also important holders of knowledge about the environment. [36,37,38] This seems to be the case even in developed-country settings, [39-41] although research on TEK in developed countries focusing on land users such as farmers or foresters is still scant. [42]

Within Europe, some synthesizing work has been carried out on knowledge about medicinal plants, [43,44] wild edible plants, [45] and hotspots of traditional cultural landscapes, where TEK is believed to be responsible for shaping landscape features, [46] such as the dehesas and montados, multifunctional agrosilvopastoral systems in southern Spain and Portugal, [47] or the traditional village systems in the forest landscapes of the Ukrainian Carpathians. [48] However, to date no comprehensive review of the current state of TEK in Europe is available. Attempting to address this knowledge gap, in this article we provide a characterization of European TEK research by answering the following questions:

- What is the analytical focus of TEK research in Europe? We explore the various definitions adopted, disciplines involved, and sociocultural groups targeted in the scholarly literature.
- Are there substantial bodies of TEK in Europe? According to the different analytical foci, we look at the sites where bodies of TEK have been documented.
- What are the locations and trends for European TEK research? We explore the geographic locations of studies reporting the state of the art and trends of existing bodies of TEK.
- Could TEK in Europe improve adaptive capacity vis-à-vis environmental changes? We provide examples of TEK-based practices across different environmental sectors that could potentially contribute toward improving the adaptive capacity of European socioecological systems.

Based on the available empirical evidence from the literature, we respond to these research questions and provide insights for further research, focusing on the potential of incorporating TEK into science-policy processes, such as IPBES.

Our results are based on a literature search using the ISI Web of Science Database, Google Scholar, and the PRIMUS database of Humboldt-Universität (Berlin, Germany). Our search targeted literature on TEK, restricting geographical coverage to European countries and using the following keywords: “traditional ecological knowledge/wisdom/practices,” “local ecological knowledge,” and “indigenous ecological knowledge.” Using combinations of these search strings, in total 41 publications responded to the query, of which 37 were eligible

studies, since they included empirical measurements of TEK within European countries. The selected studies were then codified and classified according to their authorship, year of publication, study sites, ecosystem type, examined sociocultural group, TEK definition, time frame, TEK trend, methods, core findings, and insights for policymaking. It should be noted that the overview that we present is largely limited to papers that appeared in major international journals. We stress that absence of such papers from a particular geographic region or country does by no means imply that there would not be TEK in these areas.

Portraying Traditional Ecological Knowledge Research in Europe

What Is the Analytical Focus of TEK Research in Europe?

Various definitions of TEK were identified by our systematic search. Some definitions stress the “traditional” aspect or long-term cultural continuity component of knowledge systems, [49-51] while other definitions point to the importance of the geographic specificity of this knowledge, often referred to as “local ecological knowledge.” [52-54] The former pay greater attention to knowledge as created by the coevolution of ecological and cultural systems over a long time frame, while the latter puts the focus on the knowledge that is specific to a particular ecosystem, landscape, or land use system and associated communities. Thus, studies that evaluate “local” knowledge shift the focus from a historical to a regional perspective. However, often studies do not refer to a particular definition of TEK and tend to use rather generic terms such as “farmers’ knowledge,” [55] “cultural knowledge,” [56] “traditional forest-related knowledge,” [57] or “local knowledge.” [58]

In our search, we found a wide spectrum of disciplines and scopes, including (i) disciplinary approaches focusing on the anthropological and social sides, mainly dedicated to exploring fisheries and pastoralist practices, [59-61] (ii) disciplinary approaches focusing on the biophysical side, addressing the role of TEK in sustainable practices for biodiversity and natural resource management, [62-69] and (iii) research conducted at the interface between society and ecology, specifically looking at the role of TEK in shaping features of cultural landscapes. [70-74]

In terms of research foci, we found that early studies in the 1980s were largely descriptive and focused on single species, resources, or user groups. Over time, and following a trend in TEK research in general, research on TEK in Europe has become wider in the number of subjects it encompasses and more analytical as opposed to descriptive in its approach. Nonetheless, most of the identified studies revolve around a limited set of applied questions, including (i) the role of TEK in sustainable natural resource management, [75-80] (ii) the contribution of TEK to restoring and remediating degraded ecosystems, [81-83] and, more recently, (iii) the role of TEK in building resilience to ecological and socioeconomic disturbances. [84-89]

Finally, in relation to the sociocultural groups investigated, we found that the empirical studies on TEK have targeted mostly emblematic groups within countries, serving as visible symbols of cultural heritage. For example, the TEK of the Sami, an indigenous group of nomadic herders from Scandinavia, has been thoroughly researched. [90-92] The same is true for the TEK among specific groups of Spanish farmers and pastoralists. [93-95] The traditional village systems of the Boiko people in Ukraine were also closely examined. [96]

Are There Substantial Bodies of TEK in Europe?

What Are the Locations and Trends for European TEK Research? In line with the various definitions and disciplines involved in TEK research, we found that there are in fact still-remaining bodies of TEK that have been documented in Europe. Studies on European TEK have been conducted mostly in remote areas far from highly populated nuclei and in peripheral, rather than central, parts of the continent. We found a clear inclination toward the Mediterranean (mainly Spain, Portugal, Italy, and Greece) and northern Scandinavia, but we did not find any studies from Germany, Poland, or Benelux. Only a few isolated studies on TEK have been conducted in countries such as Switzerland, [97] Turkey, [98] Ukraine, [99] and Northern Ireland. [100]

The ecosystems foci of TEK research in Europe have been the Arctic tundra, [101] high and low mountainous areas such as the Italian, Swiss, and Austrian Alps as well as the Carpathians, [102-105] or wetland areas, such as the extensive marshlands in southwestern Spain. [106,107]

More common ecosystems, such as managed forests in Germany, agricultural fields in the Netherlands, or fisheries in the North Sea, have not been covered. Arguably, this might be due to the fact that industrialization, mechanization, and other culprits behind the loss of TEK have arrived later and acted with less intensity in peripheral areas, where wide expanses of land remain nonindustrialized or at least less rationalized by technoscientific criteria.

Our search reveals that considerable changes in the extent of TEK are now taking place throughout Europe. Out of the 37 studies, 21 explored local trends in TEK and 14 of these explicitly mentioned losses thereof. For example, significant losses of TEK on agriculture over the past few generations were found in Southern Spain and Western Lesvos in Greece. [108,109] These losses were attributed to a transition from a subsistence-oriented economy, depending on local ecosystems and ecosystem services as the basis of livelihood, and to a market-driven economy and industrial way of life. Similar results regarding the loss of TEK have been reported in the Alpine regions of Austria, [110] in the United Kingdom, [111] among pastoralists in the Montes Universales, Spain, [112] and in Trás-os-Montes, Portugal. [113] Another primary cause for TEK loss reported in the literature was decreased interest in traditional practices among younger generations and demographic changes in remote regions of Europe in general, which have led to a dramatic decline in generational turnover rates. [114-117] Also, inflexible governmental regulations that do not acknowledge the management experience of local farmers can lead to loss of TEK associated with ecosystem management. This has been the case in the context of Carpathians [118] and Austrian grasslands [119] and strictly protected areas in southwestern Spain. [120]

Overall, few examples of stable trends in TEK were found in our literature review, suggesting that these bodies of knowledge are changing rapidly over time. Exceptions include the Doñana study case, where it was found that TEK associated with pastoralism and livestock raising remained stable across the past three generations, [121] although TEK associated with agriculture has been in decline. In farming areas in Sweden, active transmission of both old and new farming practices between groups and to new generations has been found. [122]

Could TEK in Europe Improve Adaptive Capacity Vis-à-Vis Environmental Changes?

Most studies indicate that TEK could contribute toward improving environmental management in Europe by sustainably managing natural resources, fostering biodiversity conservation, or enhancing adaptive capacity to environmental change. The studies examined

refer to a broad array of environmental management sectors, focusing on forestry, agriculture, fisheries, and nature conservation, as well as addressing cross-sectoral issues such as socioecological resilience and adaptive capacity to cope with change (Figure 1). The studies concerning forestry management stress the importance of TEK for implementing sustainable natural resource management. It has been suggested that systematic historical assessment of relevant traditional forest uses would enable scientists to better evaluate human activities impacts on forest ecosystem dynamics. [123] For instance, one study noted the existence of corporation woodlands, remaining from common property lands that prevailed in central Spain during the Middle Ages, which have allowed people to maintain some traditional practices related to agricultural collectivism in Spain. [124] This is also the case for TEK among communities of the Ukrainian Carpathian Mountains, where traditional village systems have provided valuable support for longterm sustainable forest management. [125] Further concrete examples deal with the restoration of selective beech coppices in the Tuscan Emilian Apennines and the reconstruction of anthropogenic disturbance regimes in a forest ecosystem in the Swiss Rhone Valley by applying TEK. [126,127]

Regarding the role of TEK in contributing to resource management in the European agricultural sector, the studies have pointed toward the importance of farmers' knowledge for improving the sustainability of land use management. For example, studies suggest the importance of traditional agricultural practices in remediating highly polluted soils [128] and the relevance of farmers' knowledge for collecting information on past and present cultural landscapes in northwestern Spain. [129] It has been argued that understanding existing traditional grassland management in the Romanian Carpathians [130] and Spanish Pyrenees [131] could greatly help to improve our ability to preserve biodiversity in traditionally managed farmlands. In Austria, the value of local farmers' knowledge regarding control mechanisms for addressing the potential threat to sustainable grassland management arising from the spread of the toxic plant *Colchicum autumnale* has been highlighted. [132]

While in developing countries TEK research has mainly focused on nature conservation in protected areas, our review found few examples in Europe dealing with TEK in relation to the conservation of specific species. One study used TEK to measure total species abundance of the endangered tortoise *Testudo graeca* in Almeria, in southern Spain.¹³³ The study demonstrated the existence of remarkable knowledge possessed by local shepherds on the abundance of the tortoise, sometimes giving even more precise insights than the peer-reviewed literature. It was argued that in this case TEK could contribute to better understanding and conservation of the species. There is also research on bodies of TEK associated to in situ landrace managements.¹³⁴ However, TEK might not always be useful for conservation purposes. For example, traditional folklore depicting a gecko species as poisonous may actually work against regional conservation efforts, as the local population motivated by this prejudice might eradicate the gecko on a large scale.¹³⁵

Previous research has suggested that TEK can be critical to the survival and well-being of traditional societies worldwide. [136] Although there is scant evidence about such contributions in developed countries, the number of studies based on them is steadily increasing. One European example is the Doñana region of southwestern Spain, where locals have historically relied heavily on TEK to respond to climatic extremes, such as drought or flooding. [137] This case study suggests that by diversifying resources, skills, and practices, the local communities can spread environmental risks across spatial and temporal scales (Box 1).

In another case study in Spain, traditional pastoralist practices were found to contribute toward diminishing the frequency and severity of wildfires (through removal of stored biomass via grazing), whose occurrence has increased with the abandonment of traditional management practices. [138] Other aspects of TEK systems that are believed to increase societies' adaptive capacities include collective pasture monitoring, shrub control, and forest thinning. [139] For example, TEK among Swiss Alpine farmers was of vital significance for adaptive management of the local environment and for households' capability to deal with socioeconomic changes. [140] As in other parts of the world, it was highlighted that traditional diversification of farm products (milk, meat, biodiversity credits, etc.) made farmers less vulnerable to external changes, such as market fluctuation of milk prices. In Sweden, as in other parts of the world, traditional agricultural practices work as insurance against ecosystem disturbances. This could become quite important in times of extensive drought or flood in agricultural hotspots around Europe. [141]

Conclusions and Policy Recommendations

Our analysis shows that researchers are becoming increasingly aware of the value of TEK for the resilience and sustainability of resource systems and associated communities in the European context. Yet the overall body of literature in the field still reveals itself to be highly fragmented and restricted to case studies in remote and rather isolated areas. Moreover, most of the studies do not adopt a particular, precise definition and show an uneven understanding of TEK, thus limiting options for comparability across case studies.

Another important finding from our study is that TEK research in Europe has focused on emblematic communities in remote regions of the periphery of Europe, probably due to the fact that industrialization arrived later to such areas and often in an incomplete form. The lack of representation of central Europe does not necessarily imply an absence of TEK in those areas. It is possible that relevant traditional knowledge for natural resources management and environmental policy does indeed exist there. Yet the issue of whether this knowledge is handed down from generation to generation and can be regarded traditional or lay knowledge needs to be reconsidered. Therefore, a revision of the classical definition of TEK may be desirable within the European context.

Substantial bodies of TEK have been reported in Europe. However, they show declining trend levels in almost half of the studies we investigated. Loss of TEK is attributed to a variety of factors, including transition from subsistence-oriented economies to market economies, rural abandonment and associated demographic changes in remote regions of Europe, decreased interest in traditional practices by younger generations, and rigidity in regulations that do not reflect the experience of local farmers in ecosystem and natural resource management.

Finally, our search suggests that there is wide evidence of the potential benefits of TEK for implementing sustainable management practices across environmental sectors (e.g., forestry, agriculture, or conservation), contributing to increased socioecological resilience and adaptive capacity to deal with change, especially among European communities whose livelihoods depend directly on natural resources and ecosystems services. This aspect is becoming increasingly important in the context of the adaptation challenges emerging with accelerating climate and other global environmental change.

Based on our findings, we suggest some basic steps to move forward the agenda on TEK research in Europe and to better mainstream this knowledge into environmental policy processes such as IPBES:

- Promote the establishment of an interdisciplinary knowledge network to build a collaborative TEK concept in Europe. Such a network could encourage participatory research in which different TEK holders define the research questions and the relevant evidences for answering them. As a result, long-term processes that allow different approaches to knowledge could emerge, enabling comparability and aggregated findings at the European level.
- Develop a strategic research plan to assess the state and trends of European TEK bodies, including underresearched areas, such as central parts of Europe.
- Identify indicators within traditional monitoring systems (e.g., pasture condition) [142] to systematically assess TEK dynamics in Europe. Such indicators could be helpful for IPBES and other policy processes.
- Research the relationship between TEK and ecosystem services delivery.
- Document and inform regional policymakers on beneficial traditional practices successfully used by locals in different environmental sectors (e.g., fisheries, forestry, and agriculture), as well as provide recommendations on how to articulate them into local environmental policies and management plans.

These actions would be operationally feasible within the Biodiversity Knowledge Network [143] in Europe where different bodies of knowledge including TEK will be interconnected. Therefore, a common framework with the peculiarities and idiosyncrasies of TEK within the European context could be created and brought to International Expert and Stakeholder Workshops on the Contribution of Indigenous and Local Knowledge Systems to IPBES. Moreover, the implementation of the new Common Agricultural Policy of the EU at a regional scale, particularly the measures under the European Agricultural Fund for Rural Development program, could include the funding of participatory action research aiming at integrating TEK into sustainable landscape management at local scales.

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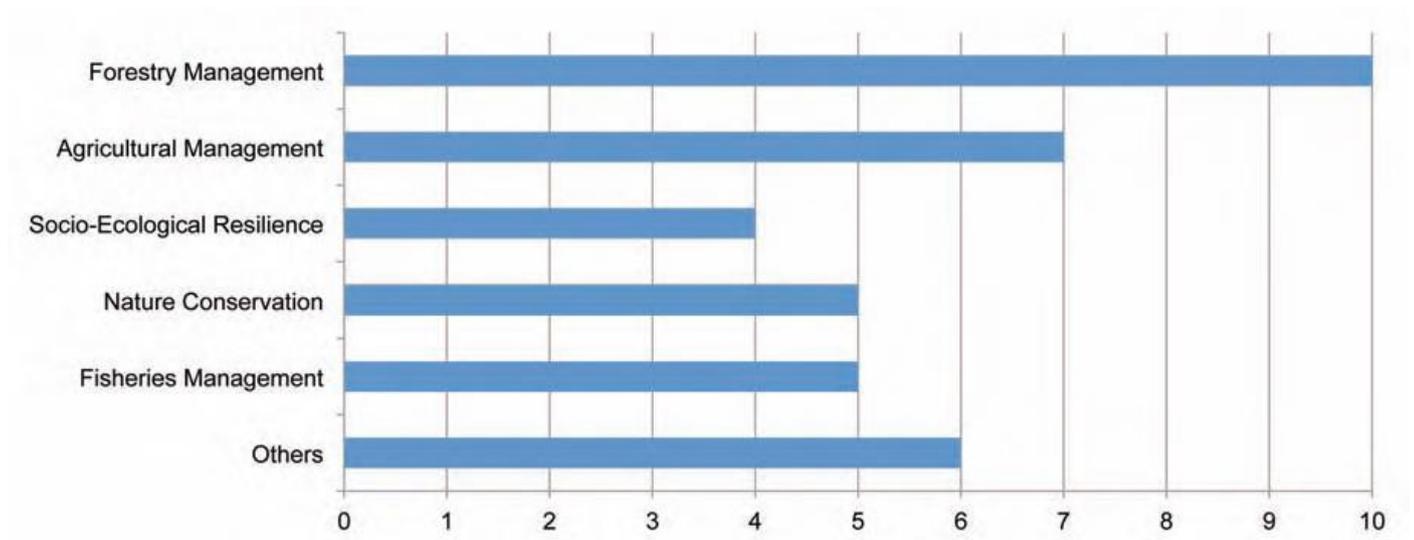
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Figure 1.

Number of studies on traditional ecological knowledge in Europe across environmental sectors.



Box 1. Traditional ecological practices of a rural population for dealing with climate change in Doñana, Spain

Doñana consists of a system of marshes, dunes, and beaches that covers approximately 2,120 km² along the coastal plain in southern Spain. It is the largest wetland in Spain and one of the most emblematic in Europe, due to its highly diverse and well-preserved ecosystems. Doñana has been distinguished through different mechanisms of protection, including being designated as a National Park, a Ramsar site and a UNESCO World Heritage Site.

Climatic variability and the unpredictable occurrence of water extremes, especially droughts, have throughout history pressed Doñana resource users to develop adaptive practices to respond to variability and change. Because sophisticated modern technologies were largely absent until the 1960s, TEK is believed to have played a central role historically in response to environmental disturbances and associated crises. Through trial and error, local users progressively developed a range of practices and institutions to cope with such change. The primary holders of the remaining TEK in Doñana are elders, and there is evidence of limited transfer to young generations, with an abrupt break in the intergenerational transmission due mainly to the mechanization of resource systems following the region's integration into the broader market economy and the partial exclusion of local users from ecosystem management following declaration of its nature protection areas.

Allowing traditional knowledge to vanish may reduce adaptation options in the face of environmental change. Any attempt to create new management and governance approaches to meet the challenge of increased uncertainty due to global environmental change should draw not only on traditional ecological knowledge, but also on the social-ecological memories embedded in local cultures, as an important complement to science and technology for creating governance and management systems that are attuned to local contexts and for building long-term social-ecological resilience.

Summary of Adaptive Practices for Coping With Disturbances Among Users of Traditional Resource Systems in Doñana, as Reported by Local Informants and in Documentary Sources

Strategy	Description	Examples
Forecasting	Observation of meteorological indicators to forecast changes in weather	Dominance of winds from the southwest as a primary indicator to forecast rainfall. Shapes of the clouds, moon cycles, bird migrations, behavior of insects, and locations of nests believed to be informative of weather changes. Traditional prognostication, known as cabañuelas, claims to predict the weather of the entire year from observations during the 31 days in January

Box 1 (continued). Summary of Adaptive Practices for Coping With Disturbances Among Users of Traditional Resource Systems in Doñana, as Reported by Local Informants and in Documentary Sources

Strategy	Description	Examples
Mobility	<p>Periodical movement to minimize exposure to risks and environmental hazards</p> <p>Transhumant shepherding practices</p>	<p>Reallocation of family homes when flooding risks increase.</p> <p>Moving of livestock to more elevated parts of the marshland or to sandy aeolian sheets during heavy rainfall.</p> <p>Absence of fences and common property systems has facilitated seasonal movement of sheep and livestock in accordance with resource availability.</p>
Storage	<p>Physical infrastructures for storage</p> <p>Customary devices for storing traditional ecological knowledge and collective memory</p>	<p>Grain stored in silos administered by local authorities and provided to applicants in times of scarcity.</p> <p>Local proverbs, tales, and storytelling as a means of storing collective memory often related to optimal dates for seeding, harvesting, and other agricultural practices.</p>
Rationing	<p>Regular adjustment of harvesting intensity to suit ecological productivity</p> <p>Limiting consumption in times of scarcity</p>	<p>Hunter associations regularly adjust the number of licenses and beats per season according to game availability.</p> <p>Size of irrigated fields periodically adjusted depending on the rainfall.</p>
Selection	<p>Selection of species and varieties adapted to local environmental conditions, especially drought</p> <p>Vernacular architecture</p> <p>Settlement planning to minimize risk</p>	<p>Agriculture based on drought-resistant olive trees, grapes, and cereals.</p> <p>Selection of the cattle variety vaca mostrenca for its ability to move and survive in the marshland when flooded.</p> <p>Use of climate-adapted building materials. Huts were constructed of materials from marsh vegetation that is resistant to humidity and insects.</p> <p>Huts and home gardens were located at the most elevated parts of the marsh (vetas) to minimize exposure to flooding.</p>

Box 1 (continued). Summary of Adaptive Practices for Coping With Disturbances Among Users of Traditional Resource Systems in Doñana, as Reported by Local Informants and in Documentary Sources

Strategy	Description	Examples
Pooling	<p>Pooling of resources, infrastructures, and labor among resource users</p> <p>Sharing or linking of assets of wealth, labor, and knowledge across social groups</p>	<p>Common property systems. Cooperatives of resource users to buffer oscillations in market prices through storage.</p> <p>Sharing of wealth, labor, and knowledge within households, among households, and within communities.</p>
Diversification	<p>Diversifying and developing redundancy of resources to spread risks across space and time</p> <p>Diversification of income, sources, and skills to spread disturbance-related risks</p>	<p>Ecosystem management for multifunctionality of landscapes.</p> <p>Seasonal spreading of production to ensure harvest of food throughout the year.</p> <p>Institutionalized limits to the division of labor. Locals shifted among different activities according to resource abundance and price oscillation.</p>