Sustainability Science
https://doi.org/10.1007/s11625-022-01155-6

ORIGINAL ARTICLE

Biocultural conservation systems in the Mediterranean region: the role of values, rules, and knowledge

Tobias Plieninger[1,2] · Yaser Abunnasr[3] · Ugo D'Ambrosio[4,5] · Tianyu Guo[1] · Thanasis Kizos[6] · Laura Kmoch[2] · Emmeline Topp[2] · Elsa Varela[7]

Received: 5 November 2021 / Accepted: 4 April 2022

Abstract

The Mediterranean Basin is a global biodiversity hotspot, but formal conservation approaches have not been wholly effective to halt species and ecosystem losses in this world region. There is wide agreement that maintaining traditional and diverse land-use systems is key to conserving biodiversity across the Mediterranean region. Biocultural approaches provide a perspective to understand and manage the interplay of nature and culture in various contexts. To develop biocultural systems as positive alternatives to unsustainable land-use systems requires an understanding of the decision-making contexts that enable such approaches. The aim of this synthesis study is therefore to compare how four biocultural conservation systems in the Mediterranean are shaped by values, rules, and knowledge. Our study is based on a synthesis of the literature published on agdal (Morocco), communal forests (Spain), sacred natural sites (Greece), and hima (Lebanon). Our synthesis shows that instrumental, intrinsic, and relational values are all fundamental components of the systems studied. Instrumental values, such as the provision of fodder or firewood, are central, and are often the result of a careful adaptation to the uncertainty inherent to Mediterranean climatic conditions. Systems like agdal and hima have originally been shaped by informal rules (often with the primary motivation to ensure equitable resource use and frequently involving taboos) and were then formalized to varying degrees. All four systems are strongly driven by local knowledge. We conclude that biocultural systems in the Mediterranean represent "people and nature" approaches that support linkages between nature and human well-being. Fostering biocultural conservation in the Mediterranean requires navigating multiple interlinkages between values, rules, and knowledge in decision-making.

Keywords Community-based conservation · Values-rules-knowledge framework · Local ecological knowledge · Relational values · Protected areas · Biocultural diversity

Handled by Hayley Clements, Stellenbosch University, South Africa.

✉ Tobias Plieninger
plieninger@uni-goettingen.de

[1] Department of Agricultural Economics and Rural Development, University of Göttingen, Platz der Göttinger Sieben 5, 37073 Göttingen, Germany

[2] Faculty of Organic Agricultural Sciences, University of Kassel, Steinstr. 19, 37213 Witzenhausen, Germany

[3] Department of Landscape Design and Ecosystem Management, American University of Beirut, Riad El Solh, P.O. Box 11-0236, Beirut 1107 2020, Lebanon

[4] Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, Kent, UK

[5] Etnobiofic Research Group, Institut Botànic de Barcelona (IBB-CSIC-ICUB), Universitat de Barcelona, Passeig del Migdia, s/n, 08038 Barcelona, Spain

[6] Laboratory of Rural Geography and Precision Farming Systems, Department of Geography, University of the Aegean, University Hill, 81100 Mytilini, Greece

[7] Forest Science and Technology Centre of Catalonia (CTFC), Ctra. Sant Llorenç de Morunys, km 2, Solsona, 25280 Lleida, Spain

Published online: 11 May 2022

Introduction

The Mediterranean region, a world area covering 2.3 million km^2 and 23 different countries, has long been renowned as a global biodiversity hotspot (Myers et al. 2000). High levels of plant and animal richness and endemism (Blondel et al. 2010; Cuttelod et al. 2008; Underwood et al. 2009b) have been supported by multiple interacting factors from biogeography, geological history, landscape ecology, and human history (Blondel et al. 2010). However, the outstanding biodiversity of the Mediterranean region is under pressure as a result of global environmental change (Underwood et al. 2009b), including a strong vulnerability to climate change (Schröter et al. 2005). Mediterranean ecosystems are particularly threatened by land-use changes, such as conversion to irrigated crops, pasturelands, urban areas, and tourism-related development (Debolini et al. 2018). Frequent fires, logging of remaining native woodlands, exotic species invasion, and intensive grazing have been reported as further threats, and the magnitude of these threats is increasing (Underwood et al. 2009b). There are striking contrasts in these threats between the Northern and the Southern fringes of the Mediterranean, in particular regarding demographic trends, political stability, socio-economic realities, and land-use pressures (King et al. 2014). Ecosystems at the Southern part of the Mediterranean have experienced agricultural intensification pressures, particularly in the fertile lowlands. In contrast, many agroecosystems in the Northern part of the Mediterranean (notably in mountain areas and on islands) have been undergoing land abandonment (Debolini et al. 2018), with increased wildfire hazards being a direct consequence (Varela et al. 2020).

Formal conservation through establishment of protected areas is an important tool to counter these pressures, but coverage of protected areas is low in the Mediterranean region. Grassland, woodland, and forest ecosystems are particularly underrepresented in these networks (Underwood et al. 2009a). The extent of protected areas varies strongly between the Northern EU member countries (subject to EU Nature Conservation Directives) and the Southern/Eastern non-member countries of the Mediterranean (UNEP-WCMC et al. 2018). As in other parts of the world, protected areas have often been planned and managed in a top–down fashion, neither considering the land-use interests of local communities nor the local ecological knowledge that they might contribute to biodiversity conservation (Kilani et al. 2007). However, heterogeneous cultures and their complex land-use systems have shaped Mediterranean ecosystems for more than 10,000 years (Bugalho et al. 2011; Grove and Rackham 2003). A large part of biodiversity is located in agroecosystems and on private lands, but most conservation strategies have not specifically addressed these ecosystems, for example, through integrated "people and nature" approaches (Mace 2014). In consequence, the EU Biodiversity Strategy has been unable to halt the decline of Mediterranean farmland bird populations (Palacín and Alonso 2018). Calls have been expressed to consider semi-natural lands outside protected areas more intensively for nature conservation in the Mediterranean region and to manage these lands jointly for biodiversity and other uses (Cox and Underwood 2011). Such management would recognize the deep-rooted history of land use and practices that have shaped and maintained habitats of exceptional biodiversity, and thus integrate multiple instrumental, intrinsic, and relational values of nature (Lomba et al. 2020).

Across the Mediterranean region, there is wide agreement that maintaining traditional and diverse land-use systems and practices, strengthening of local food systems, and better coordination of actors are critical to achieve Sustainable Development Goals (Esgalhado et al. 2021; García-Martín et al. 2020). A clearer link to a more comprehensive sustainable development agenda has been explicitly expressed for biodiversity conservation in the Mediterranean region (Kilani et al. 2007). Biocultural approaches provide a perspective to understand and manage the interplay of nature and culture in various contexts and thus offer such pathways toward sustainability in landscapes with a long agricultural history (Barthel et al. 2013b; Hanspach et al. 2020). Defined as "conservation actions made in the service of sustaining the biophysical and socio-cultural components of dynamic, interacting, and interdependent social-ecological systems" (Gavin et al. 2015), they have potential to harmonize resource use and conservation. Biocultural systems typically assemble a mosaic of land-use practices, developed in response to environmental fluctuations and being transmitted across generations through rituals, oral traditions, rules, and other processes (Barthel et al. 2013a). Awareness for the importance of biocultural approaches has been expressed in policy strategies such as the "Joint Programme on the Links between Biological and Cultural Diversity" of UNESCO and the "Charter of Rome on Natural and Cultural Capital" of the European Union (Plieninger et al. 2018). Biocultural approaches offer creative ways for engaging and living with biodiversity (Buizer et al. 2016). But despite the promise of biocultural approaches, they should not be taken up without reflection, as in some cases they have been linked to social exclusion, unjust practices, and biological deterioration. For instance, homogeneous groups often develop strong place attachment, and such homogeneity may lead to exclusion when a community becomes protective of this place (Vierikko et al. 2016).

Where biocultural systems offer positive alternatives to unsustainable land-use systems, it is helpful to determine

the decision-making contexts that enable these approaches. The decision-making context for social-ecological systems can be explored through the values-rules-knowledge (vrk) framework, which considers the different forms of values, rules, and knowledge held by decision-makers, and the interplays among them (Colloff et al. 2017). This framework recognizes values as importance or worth attributed to nature, as well as motivations, principles, and moral framings that guide decision-making (Colloff et al. 2017; Solomonsz et al. 2021). Rules can be considered as formal and informal governance arrangements, and knowledge as both evidence and experiential-based understanding (Gorddard et al. 2016). Plural valuation of landscapes, which addresses intrinsic, instrumental, and relational values, has been repeatedly highlighted as vital for effective biodiversity conservation (Díaz et al. 2015; Pascual et al. 2017). Recognizing the diversity of rule and knowledge types is also central to assessing the influences on social-ecological systems (Ostrom 2009; Tengö et al. 2014). Key to the vrk framework is understanding the pairwise linkages between these different elements, namely between values and rules, rules and knowledge, and values and knowledge. Rather than a simple model where vrk elements are considered as independent, the vrk framework emphasizes the continual ongoing interactions among these elements, which have been described as the building blocks of choice (Colloff et al. 2018). The framework is particularly suited to analyzing not only the structure of social systems, but also the agency of actors within the system, and can shed light on constraints or enablers to the decision-making process (Colloff et al. 2018). For example, conservation programs may be based on rules and knowledge related to threatened species, limiting consideration of other ecosystem and landscape values that could enhance the attainability and adaptability of conservation objectives (Colloff et al. 2018). To date, the vrk framework has been applied to climate change adaptation (Gorddard et al. 2016; Prober et al. 2017), ecosystem service provision and water use (Colloff et al. 2019; Solomonsz et al. 2021), and conservation of critically endangered ecosystems (Topp et al. 2021). It has proven particularly useful for making sense of the decision context, considering the legitimacy and feasibility of particular land management approaches and identifying strategies for change (Gorddard et al. 2016). Thus, by understanding the decision-making context, we can identify the enabling and constraining factors to the future resilience of these systems.

In this synthesis, we focus on biocultural conservation systems in the Mediterranean region that have been scientifically understudied and politically ignored or targeted by privatization or nationalization agendas—thus marginalizing the role of local communities in ecosystem stewardship. The aim of our study is to compare how four biocultural conservation systems in the Mediterranean are shaped by values, rules, and knowledge. Our study is based on a synthesis of the literature published on agdal (Morocco), communal forests (Spain), sacred natural sites (Greece), and hima (Lebanon). We argue that these four land-management systems represent "people and nature" approaches that support linkages between nature and human well-being (Armitage et al. 2020; Mace 2014). Given the strong social-ecological contrasts between North and South, East and West, we believe that the Mediterranean region provides a useful microcosm for the study of different biocultural systems that yield insights of relevance for global conservation science.

Method

For this synthesis, we selected and compared four biocultural conservation systems (Table 1) that are found in the four (Middle Eastern, North African, South-Western European, South-Eastern European) quadrants of the Mediterranean region (Fig. 1). The four cases (Fig. 2), covering both Mediterranean lowland and mountain ecosystems, were identified through work within the cross-Mediterranean research project LandscapeChains and the 2017–2020 Action Plan on "Promoting sustainable land-use practices" (M6) of the MAVA Foundation. Our selection criteria for these cases were the following:

(a) The approaches represent ancient land management systems, developed over centuries, and are thus time-tested.
(b) They are based on collective action among local communities.
(c) They are regionally distinct (though occurring in various expressions in a particular region of the Mediterranean).
(d) They integrate conservation and production aspects (but protect some natural resources from harvesting).
(e) They left strong cultural imprints on ecosystems and landscapes, often to the benefit of biodiversity.

For each of the four systems, we performed an integrated literature review (Rawluk et al. 2019). We searched for scientific literature in the "Web of Science—Core Collection" and "Google Scholar" databases, using "agdal", "communal forests" (in combination with "Spain"), "hima" (or "hema"), and "sacred natural sites" (in combination with "Greece") as keywords. We included one local expert on each of the four systems as co-authors. They pointed to additional literature and provided contextual knowledge on each case. Finally, our synthesis considered 26 studies on agdal, 31 on communal

Table 1 Geographic and socio-economic characteristics of the four biocultural systems

Biocultural system	Landscape formation	Brief definition	History	Approximate extent	Threats	Key references
Agdal, Morocco	Highlands	Communally managed (silvo-) pastoral resources; tribal customary governance systems regulating resource access and temporal closure	> 4000 years	Variable; > 1000 ha per site	Policy changes, breakdown of customary rules and institutions, privatization and illegitimate exploitation, rural abandonment, climatic stressors	Auclair and Alifriqui (2012), Auclair et al. (2011), Domínguez (2013), and Dominguez et al. (2012)
Communal forests, Spain	Mountain	Forests collectively owned or managed by the neighbors of a rural settlement	600–1600 years	Around 200 ha	Land abandonment, increasing aridity, wildfires, pests, diseases	Guadilla-Sáez et al. (2020), Iriarte-Goñi (2002), and Molina (2007)
Sacred natural sites, Greece	Mountain	Forests and trees of spiritual importance for people and communities	100–400 years	Up to 117 ha	Mechanization, simplification of land use, rural outmigration	Avtzis et al. (2018), Govigli et al. (2021), and Stara et al. (2015)
Hima, Lebanon	Mountain	An area of vegetated land to which access and use are limited by specific rules	> 1400 years	250 ha	Changes in livelihoods, land conversion, overgrazing, deliberate dismantling of the system due to centralized regulation on conservation	Gari (2006), Kilani et al. (2007), and Serhal et al. (2011)

forests, 14 on sacred natural sites, and 17 studies on hima that included relevant information on the functioning of these systems and the values, rules, and knowledge around them. The primary literature included both peer-reviewed scholarly publications and technical reports (published by government agencies and non-governmental organizations, NGOs). Most of the considered literature has been written in English, but relevant publications in local languages (French, Greek, Spanish) were also included. As many of the authors who published the primary studies were based in Greece, Lebanon, Morocco, and Spain, we believe that their views on the four systems reflect the local realities well, but acknowledge that we may have missed some local sources that are difficult to locate in our review. The respective reference lists can be found in the Supplementary Material.

In our analysis, we used a narrative approach to "standardize country-specific information along a common storyline" (Jepsen et al. 2015, p. 55). Narratives have frequently been applied in land-use science, from regional to national scales (van Vliet et al. 2015). For each of the four systems, we thus compiled a narrative of four to six pages. Information was categorized into five themes. Under "Background" we assembled information on the basic functioning of the system, its history, geographic distribution, and spatial extent. In line with the vrk framework, the next three categories used for coding were "Values", "Rules", and "Knowledge". The final category was "Potential for conservation" where we assembled the information on the opportunities of the respective biocultural system for biodiversity conservation.

Following the Intergovernmental Panel on Biodiversity and Ecosystem Services (Pascual et al. 2017), we classified values according to their instrumental, intrinsic, and relational expressions (Table 2). Instrumental are utilitarian values that serve as means to a certain end, often being assessed through economic valuation. In contrast, intrinsic values consider the value of ecosystems as ends to themselves, emphasizing aspects of deontological ethics, responsibility, and moral duties (Arias-Arévalo et al. 2017). Relational values are a third dimension, referring to those values arising from the relationships, ethics of care, and responsibilities between people and nature and between people (Chan et al. 2016). We acknowledge that this value framing, while covering a plurality of values, is not exhaustive and that broader conceptualizations of values exist across scientific disciplines. These may include other social, cultural, and transcendental values that shape individual behavior and collective action (Kenter et al. 2015; Raymond and Kenter 2016). We chose to focus on intrinsic, instrumental, and relational values given their central role in the IPBES approach and their previous application in the vrk approach (e.g., Colloff et al. 2017). We categorized rules into legislation, market arrangements, conservation agreements, and informal rules (Table 3). Informal rules may include customs,

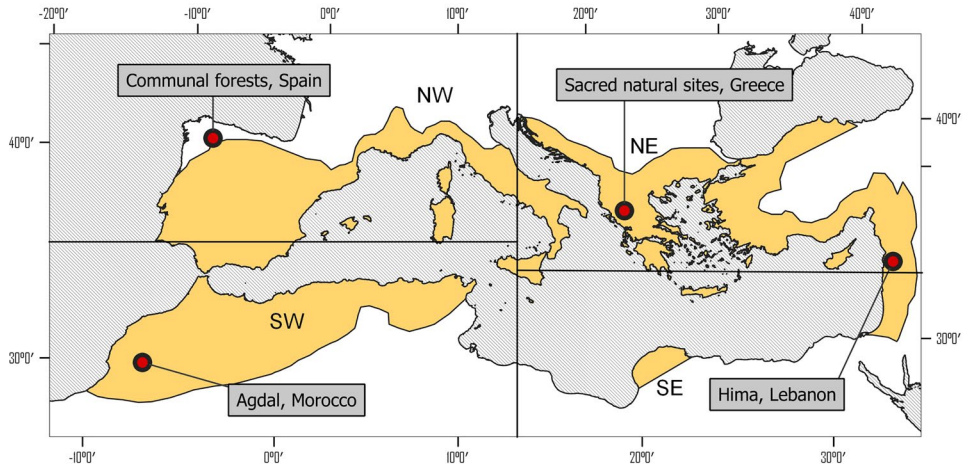

Fig. 1 Location of the four biocultural systems in the Mediterranean region

Fig. 2 Examples of agdal (top left, Igourdan, High Atlas, Morocco, Photo: Tobias Plieninger), communal forests (top right, Espejón, Spain, Photo: Pedro Agustin Medrano Ceña), sacred natural sites (bottom right, Mikro Papingo, Greece, Photo: Kalliopi Stara), and hima (bottom left, Aitanit, West Bekaa, Lebanon, Photo: Shalimar Sinno)

Table 2 Overview of instrumental, intrinsic, and relational values expressed in the four biocultural systems

Values	Agdal	Communal forests	Sacred natural sites	Hima
Instrumental	Fodder in periods of scarcity, water, animal products, tourism	Forage, fuel, charcoal, acorns, timber, drinking water, recreation, tourism, land for construction	Buffer against soil erosion, protection against landslides and floods, reservoir of timber and fodder	Fodder, wild food, timber, insurance, rangeland rehabilitation
Intrinsic	Symbols of life and baraka ("blessing")	Ecocentrism, ecological balance	Home of gods and saints	Implementing the word of God, provision of life support system
Relational	Tribal belonging, spiritual values, social organization, equitable resource use, interaction between distant groups	Sense of place, social relations, learning, mythical values	Places of worship, cultural knowledge, traditions, unique way of life	Equitable resource allocation, local traditions, Muslim beliefs

Table 3 Overview of rules expressed in the four biocultural systems

Rules	Agdal	Communal forests	Sacred natural sites	Hima
Legislation	Legal pluralism, misfit between customary and statutory governance	Municipal ordinances, management boards	Application of state forest administration	Islamic law, no formal protection
Market arrangements	Attraction of agribusiness investments	Attraction of timber companies and lately renewable energy investments	Development of new economic uses (timber/wood) in rare cases	Development of new economic uses (e.g., ecotourism)
Conservation agreements	NGO efforts aimed at indigenous and community conserved areas (ICCAs) recognition	Arrangements between regional governments and land stewardship initiatives	-	Collaboration by local communities and conservation NGOs
Informal rules	Customary rules, regular re-negotiation and adaptability of practices, land access through social belonging	Distribution of shares and quota allocation, fixing of times and areas of exploitation	Local and religious rules, taboos, beliefs	Cost–benefit adjustment, flexible rules, consensus base, permanent monitoring, sanctioning mechanisms

habits, agreements, or norms related to natural resource use. Knowledge (referring to the ways of knowledge applied to the biocultural systems) was coded into local ecological knowledge, technical knowledge, and scientific knowledge (Topp et al. 2021) (Table 4). Local-ecological knowledge is considered to be knowledge derived from local history, observation, and experience, whereas scientific knowledge stems from research sources and institutions. We consider technical knowledge to be knowledge related to natural resource management specialists, such as forestry extension staff and NGO staff.

Following Jepsen et al. (2015) and Wolpert et al. (2020), we first compiled a template narrative for one of the systems (the hima system). This template was in a second step used to structure the information on the three other systems. Each narrative was written by one or two co-authors. Third, the narratives were then reviewed by the first author for clarity and consistency and, fourth, revised by the narrative authors. In a fifth step, short synthesis texts were written on each category (presented in the results section), and background, values, rules, and knowledge of the four cases were systematically compared in tables. The four narratives are included as Supplementary Material.

Results

System characteristics

Agdal, Morocco

Agdal in rural Morocco is a system in which access to certain agrosilvopastoral resources is seasonally prohibited to allow for recovery during the most sensitive plant-growth period. It is characterized by collective land management through customary institutions, e.g. household assemblies (jmaa), communally selected guardians (aêssass), and laws (laôrf) that govern the periodic suspension of land users' rights. Agdal balances resource conservation with local users' interests and sustains social cohesion, long-standing cultural practices, and religious rites. Three types of agdal systems exist: (a) *highland pasture agdal*, common throughout the High Atlas Mountains and typically comprising highland grass-and shrublands; (b) *montane forest agdal*, found at elevations of 1800–3800 m and typically used as collectively managed "living fodder-reserves"; (c) *agdal of the arganeraie,* prevailing throughout Southwestern Morocco's argan (*Argania spinosa*) landscapes and defining individual households' right to harvest nuts and feed herds. Agdal has a 4000-year pastoral tradition and is based on detailed local ecological knowledge about the growth cycles of forage plants. Local people and their transhumant livelihoods,

Table 4 Overview of different knowledge types shaping the four biocultural systems

Knowledge type	Agdal	Communal forests	Sacred natural sites	Hima
Local-ecological	Climatic patterns and variability, plant growth cycles, ethnobotanical knowledge, livestock management	Coppicing, acorn production, rotational grazing, controlled burning	Small-scale and differentiated use of non-timber forest products, understanding of forest history through observation of vegetation succession	Terracing, rainwater harvesting, maintaining wildlife
Technical	NGO-led documentation, ecological monitoring, knowledge sharing, conservation and land-rights advocacy	State forest service-driven timber production, soil conservation	State forest service-driven soil conservation, wildfire fighting	Threats through development projects, some NGO-led promotion
Scientific	Land use and governance, religious traditions, cultural heritage, biodiversity conservation	Widely available, mostly on social processes	Biodiversity conservation, cultural history	Generally scant, only disciplinary knowledge available

cultural rituals, and collective management are at the center. However, traditional rituals and customary practices are now in gradual decline. Public policies further aim to privatize and commodify agricultural land to attract agribusiness investments, thereby threatening customary agdal systems and marginalizing local resource users.

Communal forests, Spain

The communal forests in Spain represent collectively managed woodlands and upland pastures that developed historically in adaptation to steep mountain conditions that are unsuitable for plowing and cultivation. Their history reaches back to the time after the invasion of Germanic tribes, when settlers were granted land privileges by the Christian kings to organize themselves in village councils and to collectively manage land concessions. Communal forests provide mechanisms that prevent peasant communities from resource overuse or plowing. Some of these included the distribution of shares or quotas for the members of the community (thereby excluding outsiders), the fixing of times and areas of exploitation, or the issuing of internal regulations to prevent logging or burning. They primarily serve for fuelwood and charcoal production, for provision of acorns, and for rotational livestock grazing. Nowadays, these communal forests are managed by municipalities or local communities. Customary use rights are still in place. The regional forest services oversee their management plans and may commission the design of technical forestry planning projects. One hotspot of communal forests are the mountain areas of inner Spain. Here, inhabitants organized themselves and pooled capital to collectively bid in state auctions and acquire forests for collective management. Another hotspot is Northwestern Spain, mostly Galicia. The forested area in common lands has grown since the 1950s, but these are facing major challenges of land abandonment, increasing aridity, and risks of wildfires, pests, and diseases.

Sacred natural sites, Greece

Sacred sites, including isolated trees and forests, are commonly found in the Greek countryside. They have been described as the “home of gods” and represent places of spiritual importance for people and communities. Three types of sacred natural sites are found in the Pindos mountains of Greece. First, sacred forests are typically located from 600 to 1100 m elevation and have an extent of up to 117 ha. Second, individual sacred trees and sites including trees and/or thickets are often found outside of the settlements. Third, individual sacred trees also occur within the built environment, for example, next to chapels and churches. Sacred forests and trees have been mostly established during the Ottoman period from the fourteenth to the

early twentieth century. Their management was mostly based on local informal rules that have lost importance and relevance when the populations that managed them decreased significantly and rapidly after the 1950s. This was by far the most important change affecting their management. Other important recent changes are related to the mechanization of agriculture, the broken complementarity between large holdings in the plains and the dominating transhumant animal husbandry in the mountains, and rural outmigration. All these changes put the maintenance of sacred natural sites under pressure.

Hima, Lebanon

Hima is an ancient type of community-based reserves for grazing found in Lebanon. Hima means "protected or forbidden place" and refers to an area of vegetated land to which access and use are limited by specific rules. Hima has been a land management practice among tribal and nomadic groups in the Arabic Peninsula and Levant for more than 1400 years. While the hima system has persisted over centuries, political and socio-economic changes in the Middle East caused large-scale destruction and degradation in the twentieth and twenty-first centuries. On one hand, land-use modernization often made hima less relevant for people's livelihoods. For instance, hima allocated to grazing by cattle, horses, or donkeys often became obsolete when cars and agricultural machinery were introduced. More importantly, the rise of nation states in the late 19th and early twentieth century transferred tribal rights to central governments, which often led to the abandonment and decline of hima. In addition, population growth and the subsequent demands for housing, meat, and other farm products led to increased pressures on the hima, with either land conversion or overgrazing being a consequence. Hima conservation and revitalization has been promoted by non-governmental organizations in Lebanon since the 2000s, and hima has been listed as one of the four categories of biodiversity and land conservation under Lebanese law.

Values

The instrumental values of agdal systems—most notably the provision of livestock feed during times of fodder scarcity—are of utmost importance for Morocco's rural people. Agdal systems enable High Atlas communities to sustain their herds, despite the region's challenging climatic circumstances for livestock husbandry. They provide fresh feed during the hot summer months and sometimes winter fodder, mowed by local households. Some agdal types further encompass the production of tree crops (e.g., walnuts) and irrigated annual crops and fodder grasses. The manure of agdal-fed animals is an appreciated fertilizer. More recently, agdal systems also support an emerging tourism industry that capitalizes on distinct cultural practices and iconic landscapes. Analyses of the intrinsic values of agdal systems remain lacking, but they are known, for instance, to symbolize "the idea of life in the environment abundant in water". The relational values of agdal have long shaped people's connections to land and to one another. They comprise sense of place and communal belonging, and the tight linkage of resource users' religious, spiritual, pastoral, and nomadic practices as well as numerous legends sustain notions of agdal as "mystic places". Transhumant livelihoods and forms of social organization in the High Atlas have further long been intertwined with the seasonal cycles of vegetation growth.

Communal forests in Spain have instrumental values as coppice wood is used for fuel production while acorns serve to feed livestock. The transition to a post-industrial economy in the twentieth century led to a decline of many traditional uses and emergence of new ones, such as recreation and tourism. Intrinsic values are expressed in ideas of ecocentrism and maintenance of an ecological balance in communal forests, which have been emphasized in the development of forestry schools in Spain in the nineteenth century. The relational values of communal forests include sense of place, social relations, and mythical values. With the abolition of most of the commons in the nineteenth century, many of the traditional instrumental and relational values became obsolete, causing a clash between the "commodification" of communal forests (and increased focus on timber use) through the liberal reform with the needs and values of peasants. Today, "re-commoning" is taking place in some of these woodlands by creating spaces of socialization and learning, intermingling productive with socio-cultural activities linked to the communal forests.

Sacred natural sites are of instrumental value by providing a safety function for many villages in Greece. Being frequently located above settlements, they buffer against soil erosion and also against landslides and floods. In the past, they often acted as a last resource reservoir of timber and branches for grazing. Collecting and harvesting activities in these forests were extremely regulated, and they were only allowed in the context of in celebrations and festivities. The intrinsic values of these sites are related to their "sacred" and taboo nature. Different gods and goddesses were worshiped in specific places and spaces, for instance, Apollo on mountain and hill tops (being the God of the sun), Zeus/Dias on even higher mountain tops and in oak groves, and Artemis in forests and hunting grounds. While a straightforward relation between the trees and religious and/or spiritual values has been observed for individual trees close to chapels still used for worshiping local saints, for groves it has been little investigated. Generally, their sacredness is not related to specific sites of religious

worshiping but to a broad sense of a cultural legacy. Overall, the main values of these sites are relational ones, as they are linked to accumulated cultural knowledge, traditions, esthetics, and a unique way of life. Sacred natural sites also interlink the architecture of monasteries with landscapes.

Lebanese himas are, in terms of instrumental values, an essential source of fodder and of particular importance in times of drought. By that they have an insurance function, acting as a grass bank in seasons and years of low rangeland productivity. Other tangible benefits from hima are honey, medicinal and edible plants, water, birds, and fish (as sources of food). The hima system with its principles of reducing grazing pressure is also assumed to support rangeland rehabilitation, animal welfare, and sustainable management of water catchments. The intrinsic values of the hima system as perceived by people remain unknown. Relational values also play a role in hima, as the system is appreciated for allocating scarce resources equitably among local community members, for providing social security, and for giving people influence over natural resource management.

Rules

Moroccan communities' agdal practices are an inherently customary system to govern pasture resources. Men, who self-organize in community assemblies (jmaa), are the traditional household representatives in these systems. They regularly re-negotiate rules that govern community members' access to fodder, timber, and other resources. They further determine annually varying opening and closing times for highland agdal systems, and sanction rule breaches, if and when required. Agdal systems' adaptability and grounding in local cultural, political, and economic traditions lends them legitimacy and helps to mitigate resource-access conflicts. Such conflicts nonetheless arise, however, as agdal systems are subject to legal pluralism. Islamic law and French colonial rule from 1912 to 1955 have left lasting imprints on the formal governance of land in Morocco. Various land-related laws, decrees, and institutional responsibilities nowadays characterize the land-related legal system. Title deeds and formal land markets are common in urban areas, but customary land-governance practices in the High Atlas Mountains (although declining) still largely co-exist with formal state rules. Past constitutional and conservation-policy changes have paved the way for enhanced resource protection and decentralization efforts in Morocco. Yet, communities' customary land stewardship remains underrecognized, and recent policy initiatives incentivise agribusiness investments and privatization, rather than collective land management.

The importance of forest-related resources to Spanish peasant communities resulted in formal rules and customary rules—e.g., cultural practices—to manage forest commons and prevent them from overuse or plowing. The common property regime was based on distribution of shares for the members of the community, the fixing of times and areas for exploitation, the enforcement of rules, and the resolution of any conflicts that might arise. New formal institutions have often been adapted to local ones by "institutional bricolage". The management of forest commons is nowadays ruled by ordinances approved by municipalities or management boards in the case of "montes de socios" and "montes de vecinos" woodlands, with the regional forestry administration monitoring the different activities. Today, rules refer to forest grazing rights, timber harvesting quotas, and use of forest paths and roads. Decision-making is hindered by generational succession and rural outmigration of inheritors of use rights. Another challenge is the frequent lack of legal documents that certify the legitimate ownership of communal forests in inner Spain. The current 2015 Spanish forestry act enabled the creation of management boards, allowing the identified commoners to manage the woodlands, to avoid the mismanagement—and consequently deterioration—of these ecosystems. Management boards are entitled to manage the forest, including the extraction of wood and other resources.

Sacred natural sites have been governed by tacit customary rules imposed by a local (and typically religious) authority. These rules have developed to prevent their exploitation for private use. The local community acted as the custodian of a site, managing, and conserving its cultural, spiritual, and environmental values. Part of these rules were religious taboos. Mismanaging the forests was believed to cause misfortune, disease, or even death to the trespasser. The uses that are allowed or not inside them are related to the cutting of trees and other uses. Shredding, pruning, or other forms of wood extraction are regulated and typically prohibited along with felling. Activities such as livestock grazing, collection of mushrooms, and hunting also are usually allowed. These rules are today formal in the sense that these forests are now managed by the Forest Services that provide detailed guidelines on felling trees. Guidelines on other forms of harvesting may be provided, for example, regarding use of mushrooms or herbs by national or regional guidelines by the Ministry of Agriculture, Rural Development, and Food.

Hima is based on local traditions of customary management; it rests on community-based actions, public participation, equitable use and sharing of natural resources, and protection of indigenous and customary rights. With the emergence of Islam (that postulates an individual and communal duty to protect the environment and to ensure that people can fulfill their basic needs), hima was supported by formal rules as a community's common property. Hima use is controlled by local stakeholders to conserve water and vegetation in harsh environments. Rules strive for social acceptability by the actors who carry the cost of their implementation and for economic viability by generating

tangible benefits. At its core, the system regulates grazing and harvesting of different natural resources, either seasonally or permanently. Construction activities and extraction of commodities for trade or financial gains are generally interdicted. Rules are typically flexible, but well-developed and monitored locally, based on community consensus. Responsibilities, such as collecting rainwater run-off, are allocated to each beneficiary. Rule violations are sanctioned, for example, by slaughtering some of the trespassing animals or, more recently, by fines. Over the societal turmoil that Lebanon has been exposed to in the past decades, the informal and formal rules underpinning hima have been largely abolished or subsequently abandoned.

Knowledge

Local ecological knowledge is the principle type of knowledge that informs communities' management of the agdal. This includes shepherds' detailed knowledge about pasture plants growth cycles, and seasonally permissible grazing intensities. Observational knowledge of local climate patterns, inter-annual climate variability, and associated effects on grassland ecology feeds into communities' decision-making about temporal restrictions to agdal access, for instance in lower lying areas during hot summer months. Communities' understanding of endemic agdal plants' aromatic and medicinal properties is another important local knowledge strand. Technical knowledge about High Atlas agdal systems has been advanced by various NGOs, through appraisals of communities' narrative histories, transhumant practices, emerging conflicts, perceptions of societal change processes, and agdal floral diversity. At national level, they have further driven knowledge sharing, advocacy, and policy-related initiatives, e.g., to register and enhance recognition of agdal systems as indigenous and community conserved areas (ICCAs). Scientific knowledge stems from the extensive research of a few authors, who have published on agdal systems' historic trajectories and recent change dynamics, their cultural and religious significance, their adaptive governance potential and efficacy for agroforestry-landscape and grassland conservation, and—more recently—related policy processes.

Management of communal forests has long been dominated by local ecological knowledge. Local traditions shaped these landscapes through coppicing for fuelwood and charcoal production, selection of acorn-producing trees, and rotational livestock grazing. More controversial was the use of fire to expand the pastureland in mountains pastures. Local knowledge is gradually being lost due to aging of rural dwellers and reduction of rural populations depending on the forest as a source of income. Technical knowledge was introduced through forest management in the nineteenth century, with a focus on timber production and soil conservation leading to banning traditional activities that would be harmful for newly established pine afforestations. Nowadays, forest cover is steadily increasing, and the control of biomass to reduce the risk of wildfires while fostering forest biodiversity are key challenges. Scientific knowledge has mostly been focused on "montes de vecinos" woodlands located in Galicia (northern Spain) where these communal forests have been widely studied, for instance in terms of new institutional economics, principles of collective action, management conflicts, and impacts of formal institutional logics affecting commoners.

In sacred natural sites, local ecological knowledge is the primary type of knowledge. This knowledge has favored practices to manage and protect such forests from overgrazing and logging and to maintain their multiple societal values. Technical knowledge has incorporated sacred forests into typical forest management, recently through the takeover of all forest areas management by the Forest Service. Scientific knowledge on sacred forests has been published for around 30 years, focusing on their conservation values and on the historical background of their establishment and management. What is missing today is the integration of recent scientific knowledge, which largely builds on past local ecological knowledge, with current management and conservation efforts. The Forest Service provides guidelines that are related to wood/timber management only; it does not address how the forest as a socioecological unit needs to be managed. This need is underlined further by the expansion of forest areas in the region and the new management challenges that this development requires, including management of wildlife and biodiversity conservation.

The primary type of knowledge forming the basis of the hima system is local ecological knowledge. Local traditions have shaped, for instance, the establishment of agricultural terraces, the refinement of rainwater harvesting methods over time, and the maintenance of wildlife populations. This local ecological knowledge, derived and influenced by Islam (that balances conservation of biodiversity and the sustainable use of renewable natural resources), has been considered the central driver behind the objectives of biodiversity conservation through hima. Technical knowledge has typically been ignorant of the hima system. Therefore, integrated policies that support local communities in conserving the scientific, economic, social, and ethical values of biodiversity are rare. In contrast, many himas have been jeopardized by inappropriate development projects and other actions. On the other hand, himas have been promoted by state agencies in Syria from the 1960s to the 1980s and by non-governmental organizations in Lebanon since the 2000s. Some scientific knowledge on the hima system has been collected, but it is underdeveloped. Integrated social-ecological research is absent and where it exists has been unable to inform political decisions so far.

Discussion

In this synthesis, we highlight four biocultural conservation systems—agdal, communal forests, sacred natural sites, and hima—as positive examples of people-nature approaches. These traditional systems are distributed across the Mediterranean, a world region in which community-based conservation has rarely been investigated (Charles 2021), and they are typically characterized by complex agrosilvopastoral management (Wolpert et al. 2020). We drew on regional and international literature on these systems, compiling them into narratives and comparing their characteristics across cases, and analyzed them through the emerging "Values-Rules-Knowledge" (vrk) framework. This framework has previously been applied to widen options for decision-making where there is a need to adapt to climate and/or landscape change. In our synthesis, we used vrk to identify the key values, rules, and knowledge that form the biocultural characteristics of these enduring systems, with a view to ensuring their future resilience. In this discussion, we reflect on the major patterns in values, rules, and knowledge of biocultural systems in the Mediterranean, with a focus on the interactions between vrk components.

The role of values, rules, and knowledge in biocultural conservation systems

Our review demonstrated that instrumental, intrinsic, and relational values are all of paramount importance in the systems studied. Instrumental values, such as the provision of grass or firewood, are fundamental, and these values have evolved in careful adaptation to the uncertainty inherent to Mediterranean climatic conditions. The systems typically act as buffers for periods of scarcity and thus fulfill an insurance function. Relational values also showed to be of utmost importance and were often closely tied to instrumental values. For instance, livestock can have spiritual or religious values (e.g., the sacrificial lamb, considered in Christian belief a symbol of the resurrection of Jesus Christ) and instrumental values (providing meat, milk, and other tangible products) (Rodríguez-Ortega et al. 2014). Intrinsic values are typically related to religion, which had a key role in organizing rural societies and power to impact land (Zannini et al. 2021), especially when these systems were first established. The sacredness or spirituality of nature is often operationalized in specific situations as relational values (for instance, in the case of hima by fulfilling the word of God by conserving land and biodiversity to ensure meeting basic needs, Marsuki 2009)—highlighting again that instrumental, intrinsic, and relational values are closely interlinked in biocultural systems.

Systems like agdal and hima have originally been shaped by the informal (i.e. customary) rules of agrarian communities (often with the primary motivation to ensure equitable resource use and frequently involving taboos, Daw et al. 2015), and were later formalized and altered to varying degrees through state legislation. Enforcement and monitoring can be conducted by either communities or external authorities, depending on who has resources and power to do so (c.f. Rutte 2011). In some cases, it can be impossible to distinguish between customary rules and formal law. In other cases, the opposite happened, and formal rules were established that acted against such informal rules. For example, the clash between the informal rules of traditional user communities and the formal rules of the state in Spain's communal forests resulted in conflict about grazing bans and priority for timber production (Iriarte-Goñi 2002). In some regions, this ended in a devolution of decision-making to local users, while in others, it resulted in clashes between communities and the state, the effects of which are still visible today. Conflicts between villagers and state agencies about the entitlements to make decisions on forest remain unsettled in some regions and resurge when conservation legislation (e.g., the implementation of the EU Nature Directives in Spain's communal forests) imposes restrictions on land users. The co-existence of formal and informal rules, such as in Morocco, may also facilitate rule breaches and resource grabbing and thus undermine conservation goals, if powerful stakeholders play ambiguous or discrepant rule systems to their advantage. It would be interesting to study the relation of formal and informal rules more closely, in particular regarding how the success and legitimacy of formal rules may be determined by their relation to informal rules and community involvement. The objects of regulation are in all cases extractive uses (wood harvesting, grazing, etc.). Interestingly, outright destruction (e.g., clearing of habitats) is typically interdicted, while moderate, sustainable use of resources is tolerated or encouraged. Even where informal rules have not been explicitly abolished, many of them have ceased to exist in the past decades (e.g., due to rural exodus, availability of off-farm jobs, or replacement of local natural resources by external energy and nutrient inputs), leading to trajectories of either abandonment or overuse, as observed for other traditional land uses in the Mediterranean region (Plieninger and Bieling 2013).

The pattern describing use of knowledge was quite consistent among approaches, which were all strongly driven by local knowledge. In contrast, technical knowledge by forestry extension staff, or other formally trained natural resource managers, was less frequently applied. However, one such example is the uptake of hima by agricultural development specialists in Syria in the 1980s (Chatty 2001). In most other cases, and similar to the clashes between formal and informal rules, interests related to technical knowledge (in

particular those related to more intensified and monofunctional land uses, such as timber production) were in conflict with the knowledge and interests that local communities related to more diversified, multifunctional land uses. The loss of local knowledge is another common issue, typically tied to land abandonment and outward migration but also to a historic lack of recognition by technical experts and state authorities. Strategies for retaining, transferring, and developing local ecological knowledge are therefore needed across all systems as a precondition for rural renewal strategies. Use of scientific knowledge was generally underdeveloped in our systems, in particular for hima. The few studies that have been performed typically look at singular aspects and are very much driven by single disciplines (e.g. conservation biology—sacred natural sites; commons studies—communal forests) or individual researchers. Community science—an emerging field of research and monitoring driven and controlled by local communities, and characterized by place-based knowledge, social learning, collective action and empowerment (Charles et al. 2020)—has been used for agdal, but would deserve much wider application to strengthen the position of less powerful resource users, and to support the integration of multiple values, rules, and knowledges for more inclusive conservation outcomes in the Mediterranean region.

Interlinkages between values, rules, and knowledge

Our analysis framework shed light on the ways how values, rules, and knowledge are part of dynamic and interlinked processes. When one vrk element changes, this can instigate change in other elements, which together defines the enabling factors and constraints for these biocultural conservation approaches. For instance, rules embody, reflect, and are therefore determined by actors' different types of values and knowledge (Gorddard et al. 2016). The prevalence or cessation of specific values, rules, and knowledge constellations over time can thus arise from gradual socio-cultural shifts in societies or be highly political, an expression of stakeholders' dynamic power relations, which constrain or enable biocultural system change along different conservation trajectories.

Our analysis revealed that the four systems share a plurality of cultural and relational values which strongly link to informal rules and regulation of these systems (v–r interaction). For example, religious beliefs, taboos, deities, and perceived sacredness of sites prevent people from misusing or overusing areas. Thus, the rules that govern the systems can in fact be embedded in the spiritual, cultural, and relational ties to place of local communities. These v–r interactions strongly support the importance of documentation and promotion of cultural and relational values for maintaining the biocultural approaches, as demonstrated in the IPBES assessments (Hill et al. 2019). Another example of a v–r interaction enabling the maintenance of the system is in the case of ecotourism in the hima, which interlinks new actors and market arrangements with instrumental and relational values.

Rules and knowledge were also intricately related. Technical and scientific knowledge are often important for advancing the wider recognition and status of these systems (Tengö et al. 2014), as is the case with agdal and hima. This recognition can result in rule changes, such as the introduction of formal conservation legislation (r–k interaction). On the one hand this can enable the maintenance of these systems, as funding and formal protection may help with implementing management practices or monitoring. On the other hand, this may prevent communities from practicing their traditional uses, as can be the case with communal forests in Spain and many sacred natural sites worldwide. There, the introduction of top-down rules for the restriction of grazing has led to conflict, increased fire risk, and had negative implications for biodiversity (Varela et al. 2020). This r–k interaction has also been observed in woodland landscapes in Australia, where lack of availability or acceptance of scientific knowledge, alongside lack of capacity to implement this knowledge, has led to misunderstandings and conflicts over grazing and fire (Prober et al. 2017).

Knowledge-values links were influential in some of the cases. All four systems are characterized by rich local ecological knowledge, and this knowledge enables people to derive multiple values from these systems. For example, knowledge of coppicing enables communal forest users to derive forest products which are not based on short-term timber production. Thus, maintaining these systems is enabled by retaining local knowledge. When technical knowledge addresses the multiple values of the system, as in the case of agdal, it can enable promotion of these values and integrate community values and local knowledge into NGO activities. However, when technical knowledge is used exclusively, with disregard for other knowledge sources and holders, and when it has a narrow focus on resource intensification, as in the case of timber in communal forests, this can be a constraint to biocultural conservation.

Some vrk elements appear to form specific decision-making contexts. For example, local knowledge and informal rules, as well as relational and instrumental values may be seen as the foundation for traditional community decision-making in a more bottom-up approach (Fig. 3), whereas external partners and actors may rely on instrumental values, scientific and technical knowledge, and formal rules in a more top-down approach (Sodhi et al. 2011; Topp et al. 2021). However, the different vrk overlap extensively among the biocultural systems, and thus

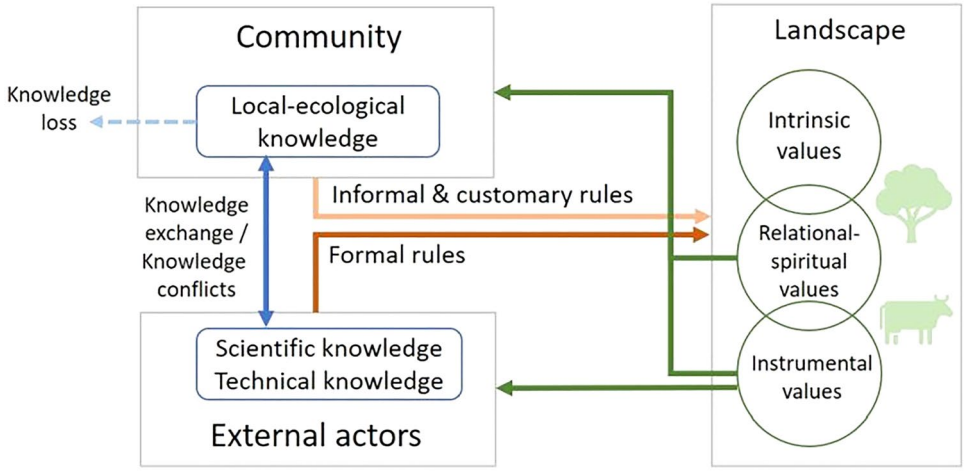

Fig. 3 Simplified representation of the role of vrk in Mediterranean biocultural systems. Boxes show elements of each of the systems. Circles show different value types derived from the landscape and their overlap. Arrows show direction of valuing (green), management (red) and knowledge flow (blue and blue dashed). Green icons represent examples of features of the landscape (trees and livestock) that can fall into multiple value categories. 'External actors' refers to e.g. local authorities and non-governmental organizations whose actions may be influenced by governmental and supra-governmental organizations. Inspired by Solomonsz et al. (2021)

the decision contexts cannot be so easily separated. For example, formal rules often take their cue from informal rules and customs. Additionally, landscape features can have plural values, such as livestock, which can be both a source of income (instrumental) and play a role in cultural practices (relational). Thus, the decision-making contexts are dynamic and multi-layered.

Conclusions

Biocultural approaches are relevant for nature conservation, but many biocultural conservation systems have been lost. Our analysis of four biocultural systems from the Mediterranean region revealed remarkable stability over time, but also a severe and concomitant erosion of societal values assigned to them, of local knowledge, and of traditional rules and practices. Some systems have been reinvented successfully, but typically at small scales and with substantial changes in values, rules, and knowledge. A key challenge is the compatibility of traditional social-ecological systems—established under specific economic, social, and cultural conditions, leading to specific arrangements of values, rules, and knowledge—with contemporary modes of governance and resources use. We conclude with some key insights from our analysis on the values, rules, and knowledge and the future perspectives of biocultural approaches that may inform broader conservation science and practice:

- The values assigned to biocultural systems are broad and often time-, actor-, and context-specific, leading to a high potential for landscape multifunctionality, but also to frequent trade-offs among different stakeholder groups. Capitalizing on these values in novel and power-sensitive ways (e.g., through inclusive conservation practices, collaborative agri-environmental schemes, or conservation-driven intergovernmental fiscal transfers) means to increase the resilience of biocultural approaches. Religious and spiritual values appear prominently in many biocultural systems and are much more stable than utilitarian values. The role of religion and spiritual practices in establishing and maintaining biodiversity-rich ecosystems and communal governance practices, and their potential for reconnecting people and nature therefore deserves more societal awareness and scientific study.
- Customary rules are key to the functioning of biocultural conservation, which have sometimes been supported, and sometimes been marginalized by formal rules. New challenges, such as increasing wildfires, require novel ways of bringing formal and informal management and governance approaches together.
- Retaining local knowledge is a priority for biocultural conservation and must be considered in light of societal trends such as rural outmigration and land abandonment. Permeability of different types of knowledge must therefore be increased, for instance by widening ongoing participatory monitoring efforts or scientific research to document local knowledge and to weave it with other relevant forms of knowledge. Growing recognition for indigenous and local knowledge within IPBES may provide an opportunity for strengthening such knowledge through biocultural conservation systems.
- Policy makers or funders at regional/national level should develop more recognition for the plurality and interlink-

ages of values, rules, and knowledge in conservation. Our analysis indicates that overcoming dichotomies that separate strictly for instance between local and scientific knowledge is key to maintaining biocultural systems. This requires an ability to navigate diverse cognitive framings. For instance, technical knowledge may be used for ensuring sufficient pruning or fodder management, while scientific knowledge serves for identifying specific species of national or international interest, and local knowledge of spiritual or relational values can help manage these ecological aspects in light of their specific cultural histories and locally important narratives. Integration of diverse types of knowledge may also allow modernization of biocultural systems (e.g., though introduction of locally adapted farm machinery) without putting their social and ecological values at risk.

- Boosting biocultural approaches in conservation requires paragons that illustrate the opportunities for conservation, multifunctional land management, and broader rural development. Such paragons can gain international visibility through designations such as intangible cultural heritage (UNESCO), Globally Important Agricultural Heritage System (GIAHS, FAO), or indigenous and community conserved area (ICCA, UNEP-WCMC). For example, GIAHS designation has often not only offered acknowledgement at national and international levels to local agricultural systems; it also increased visibility of the contributions of local people by their routine farming practices and local rituals, including the social capital that these have formed.
- Further strengthening local communities and their networks, while advocating for fair and context-based policies that promote bottom-up approaches (as announced in a new global inclusive conservation initiative by the Global Environment Facility, GEF, the International Union for Conservation, IUCN, and Conservation International, CI, in February 2022), will have a positive impact on conservation programs and outcomes. In addition, a balance between tradition and innovation is needed, to sustain the positive human-nature connections in these biocultural systems as conditions permanently change.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11625-022-01155-6.

Acknowledgements This research has been funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 426675955. Ideas leading to this study were developed within the "M6—Promoting sustainable land-use practices in the Mediterranean Basin" Action Plan of MAVA Fondation pour la Nature. This study contributes to the Global Land Programme (www.glp.earth) and the Programme on Ecosystem Change and Society (www.pecs-science.org).

Funding Open Access funding enabled and organized by Projekt DEAL.

References

Arias-Arévalo P, Martín-López B, Gómez-Baggethun E (2017) Exploring intrinsic, instrumental, and relational values for sustainable management of social-ecological systems. Ecol Soc 22(4):43

Armitage D, Mbatha P, Muhl E-K, Rice W, Sowman M (2020) Governance principles for community-centered conservation in the post-2020 global biodiversity framework. Conserv Sci Pract 2(2):e160

Auclair L, Baudot P, Genin D, Romagny B, Simenel R (2011) Patrimony for resilience: evidence from the forest agdal in the Moroccan High Atlas mountains. Ecol Soc 16(4):24

Auclair L, Alifriqui M (2012) Agdal: Patrimoine Socio-écologique de l'Atlas Marocain. IRD-IRCAM, Rabat, Marseille

Avtzis DN, Stara K, Sgardeli V et al (2018) Quantifying the conservation value of sacred natural sites. Biol Cons 222:95–103

Barthel S, Crumley C, Svedin U (2013a) Bio-cultural refugia—safeguarding diversity of practices for food security and biodiversity. Glob Environ Change 23(5):1142–1152

Barthel S, Crumley CL, Svedin U (2013b) Biocultural refugia: combating the erosion of diversity in landscapes of food production. Ecol Soc 18(4):71

Blondel J, Aronson J, Bodiou J-Y, Boef G (2010) The Mediterranean Region: biological diversity in space and time. Oxford University Press, Oxford

Bugalho MN, Caldeira MC, Pereira JS, Aronson J, Pausas JG (2011) Mediterranean cork oak savannas require human use to sustain biodiversity and ecosystem services. Front Ecol Environ 9(5):278–286

Buizer M, Elands B, Vierikko K (2016) Governing cities reflexively. The biocultural diversity concept as an alternative to ecosystem services. Environ Sci Policy 62:7–13

Chan KMA, Balvanera P, Benessaiah K et al (2016) Why protect nature? Rethinking values and the environment. Proc Natl Acad Sci 113(6):1462–1465

Charles A, Loucks L, Berkes F, Armitage D (2020) Community science: a typology and its implications for governance of social-ecological systems. Environ Sci Policy 106:77–86

Charles A (2021) Communities, conservation and livelihoods. IUCN, Community Conservation Research Network, Gland, Halifax

Chatty D (2001) Pastoral tribes in the Middle East and wildlife conservation schemes: the endangered species? Nomadic Peoples 5:104–124

Colloff MJ, Martín-López B, Lavorel S et al (2017) An integrative research framework for enabling transformative adaptation. Environ Sci Policy 68:87–96

Colloff MJ, Doody TM, Overton IC, Dalton J, Welling R (2019) Re-framing the decision context over trade-offs among

ecosystem services and wellbeing in a major river basin where water resources are highly contested. Sustain Sci 14(3):713–731
Colloff M, Gorddard R, Dunlop M (2018) The values-rules-knowledge framework in adaptation decision-making: a primer. CSIRO Land and Water, Canberra. https://doi.org/10.13140/RG.2.2.13783.11688/1
Cox RL, Underwood EC (2011) The importance of conserving biodiversity outside of protected areas in Mediterranean ecosystems. PLoS One 6(1):e14508
Cuttelod A, García N, Abdul Malak D, Temple H, Katariya V (2008) The Mediterranean: a biodiversity hotspot under threat. In: Vié J-C, Hilton-Taylor C, Stuart SN (eds) The 2008 review of the IUCN red list of threatened species. IUCN, Gland
Daw TM, Coulthard S, Cheung WWL et al (2015) Evaluating taboo trade-offs in ecosystems services and human well-being. Proc Natl Acad Sci USA 112(22):6949–6954
Debolini M, Marraccini E, Dubeuf JP et al (2018) Land and farming system dynamics and their drivers in the Mediterranean Basin. Land Use Policy 75:702–710
Díaz S, Demissew S, Carabias J et al (2015) The IPBES conceptual framework—connecting nature and people. Curr Opin Environ Sustain 14:1–16
Dominguez P, Bourbouze A, Demay S, Genin D, Kosoy N (2012) Diverse ecological, economic and socio-cultural values of a traditional common natural resource management system in the Moroccan High Atlas: the Ait Ikiss Tagdalts. Environ Values 21(3):277–296
Domínguez P (2013) Culturally mediated provision of ecosystem services: the Agdal of Yagour. In: Lozny LR (ed) Continuity and change in cultural adaptation to mountain environments. Springer, Heidelberg, pp 379–393
Esgalhado C, Guimarães MH, Lardon S et al (2021) Mediterranean land system dynamics and their underlying drivers: stakeholder perception from multiple case studies. Landsc Urban Plan 213:104134
García-Martín M, Torralba M, Quintas-Soriano C, Kahl J, Plieninger T (2020) Linking food systems and landscape sustainability in the Mediterranean region. Landsc Ecol 36(8):2259–2275
Gari L (2006) A history of the hima conservation system. Environ Hist 12(2):213–228
Gavin MC, McCarter J, Mead A et al (2015) Defining biocultural approaches to conservation. Trends Ecol Evol 30(3):140–145
Gorddard R, Colloff MJ, Wise RM, Ware D, Dunlop M (2016) Values, rules and knowledge: adaptation as change in the decision context. Environ Sci Policy 57:60–69
Govigli VM, Efthymiou A, Stara K (2021) From religion to conservation: unfolding 300 years of collective action in a Greek sacred forest. For Policy Econ 131:102575
Grove AT, Rackham O (2003) The Nature of Mediterranean Europe: an ecological history. Yale University Press, New Haven
Guadilla-Sáez S, Pardo-de-Santayana M, Reyes-García V (2020) Forest commons, traditional community ownership and ecological consequences: insights from Spain. For Policy Econ 112:102107
Hanspach J, Haider LJ, Oteros-Rozas E et al (2020) Biocultural approaches to sustainability: a systematic review of the scientific literature. People Nat 2:643–659
Hill R, Nates-Parra G, Quezada-Euán JJG et al (2019) Biocultural approaches to pollinator conservation. Nat Sustain 2(3):214–222
Iriarte-Goñi I (2002) Common lands in Spain, 1800–1995: persistence, change and adaptation. Rural Hist 13(1):19–37
Jepsen MR, Kuemmerle T, Müller D et al (2015) Transitions in European land-management regimes between 1800 and 2010. Land Use Policy 49:53–64
Kenter JO, O'Brien L, Hockley N et al (2015) What are shared and social values of ecosystems? Ecol Econ 111:86–99
Kilani H, Serhal A, Llewlyn O (2007) Al-Hima: a way of life. IUCN West Asia regional, Amman
King R, Proudfoot L, Smith B (2014) The Mediterranean: environment and society. Routledge, London
Lomba A, Moreira F, Klimek S et al (2020) Back to the future: rethinking socioecological systems underlying high nature value farmlands. Front Ecol Environ 18(1):36–42
Mace GM (2014) Whose conservation? Changes in the perception and goals of nature conservation require a solid scientific basis. Science 345(6204):1558–1560
Marsuki MZB (2009) The practice of Islamic environmental ethics: a case study of Ḥarīm and Ḥimā. University of Wales Trinity Saint David, Lampeter
Molina CM (2007) Cultural heritage, sustainable forest management and property in inland Spain. For Ecol Manag 249(1–2):80–90
Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403(6772):853–858
Ostrom E (2009) A general framework for analyzing sustainability of social-ecological systems. Science 325(5939):419–422
Palacín C, Alonso JC (2018) Failure of EU Biodiversity Strategy in Mediterranean farmland protected areas. J Nat Conserv 42:62–66
Pascual U, Balvanera P, Díaz S et al (2017) Valuing nature's contributions to people: the IPBES approach. Curr Opin Environ Sustain 26–27:7–16
Plieninger T, Bieling C (2013) Resilience-based perspectives to guiding high nature value farmland through socio-economic change. Ecol Soc 18(4):20
Plieninger T, Kohsaka R, Bieling C et al (2018) Fostering biocultural diversity in landscapes through place-based food networks: a "solution scan" of European and Japanese models. Sustain Sci 13(1):219–233
Prober SM, Colloff MJ, Abel N et al (2017) Informing climate adaptation pathways in multi-use woodland landscapes using the values-rules-knowledge framework. Agr Ecosyst Environ 241:39–53
Rawluk A, Beilin R, Bender H, Ford R (2019) Practices in social ecological research: interdisciplinary collaboration in "Adaptive Doing." Springer, Berlin
Raymond CM, Kenter JO (2016) Transcendental values and the valuation and management of ecosystem services. Ecosyst Serv 21:241–257
Rodríguez-Ortega T, Oteros-Rozas E, Ripoll-Bosch R, Tichit M, Martín-López B, Bernués A (2014) Applying the ecosystem services framework to pasture-based livestock farming systems in Europe. Animal 8(8):1361–1372
Rutte C (2011) The sacred commons: conflicts and solutions of resource management in sacred natural sites. Biol Conserv 144(10):2387–2394
Schröter D, Cramer W, Leemans R et al (2005) Ecosystem service supply and vulnerability to global change in Europe. Science 310(5752):1333–1337
Serhal A, Saidi AR, Khatib B, Jawhary D, Farah N, Khatib T (2011) The Hima: an ancient conservation system from the Arabian Peninsula for the future. In: Papayannis T, Pritchard D (eds) Culture and wetlands in the Mediterranean: an evolving story. Mediterranean Institute for Nature and Anthropos, Athens, pp 372–384
Sodhi NS, Butler R, Raven PH (2011) Bottom-up conservation. Biotropica 43(5):521–523
Solomonsz J, Melbourne-Thomas J, Constable A, Trebilco R, van Putten I, Goldsworthy L (2021) Stakeholder engagement in decision making and pathways of influence for Southern Ocean ecosystem services. Front Mar Sci 8(541):623733

Stara K, Tsiakiris R, Wong JLG (2015) The trees of the sacred natural sites of Zagori, NW Greece. Landsc Res 40(7):884–904

Tengö M, Brondizio ES, Elmqvist T, Malmer P, Spierenburg M (2014) Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. Ambio 43(5):579–591

Topp EN, Loos J, Martín-López B (2021) Decision-making for nature's contributions to people in the Cape Floristic Region: the role of values, rules and knowledge. Sustain Sci. https://doi.org/10.1007/s11625-020-00896-6

Underwood EC, Klausmeyer KR, Cox RL, Busby SM, Morrison SA, Shaw MR (2009a) Expanding the global network of protected areas to save the imperiled Mediterranean biome. Conserv Biol 23(1):43–52

Underwood EC, Viers JH, Klausmeyer KR, Cox RL, Shaw MR (2009b) Threats and biodiversity in the Mediterranean biome. Divers Distrib 15(2):188–197

UNEP-WCMC, IUCN, NGS (2018) Protected Planet Report 2018. UNEP-WCMC, IUCN, NGS, Cambridge, Gland, Washington DC

van Vliet J, Verburg PH, Magliocca N et al (2015) Meta-studies in land use science: current coverage and prospects. Ambio 45:15–28

Varela E, Pulido F, Moreno G, Zavala MÁ (2020) Targeted policy proposals for managing spontaneous forest expansion in the Mediterranean. J Appl Ecol 57:2373–2380

Vierikko K, Elands B, Niemelä J et al (2016) Considering the ways biocultural diversity helps enforce the urban green infrastructure in times of urban transformation. Curr Opin Environ Sustain 22:7–12

Wolpert F, Quintas-Soriano C, Plieninger T (2020) Exploring land-use histories of tree-crop landscapes: a cross-site comparison in the Mediterranean Basin. Sustain Sci 15(5):1267–1283

Zannini P, Frascaroli F, Nascimbene J et al (2021) Sacred natural sites and biodiversity conservation: a systematic review. Biodivers Conserv 30(13):3747–3762