



An Initial Assessment of Community Values, Rules, and Traditional Ecological Knowledge of Mount Hermon, Lebanon: Key Perspectives towards Biocultural Conservation

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Abstract

Mount Hermon, Lebanon, has a long history of human occupation reflected in the landscape and ecology that makes biocultural perspectives highly relevant for the conservation of this mountain territory. We conducted semi-structured interviews with 126 local informants during 2022–2023 using a Values, Rules and Knowledge (VRK) framework. Our findings illustrate that while instrumental values of this territory (e.g., water sources, tourism, land, and good soils for crop production) were most frequently cited by informants (50.84%), relational values (e.g., social identity, sense of place, and spirituality in human-nature relationships) also scored high (41.88%), with subjective intrinsic values of nature as an end in itself (e.g., the right of nature to exist on its own behalf) least cited (7.28%). At the same time, co-occurrence of formal rules (62.26% of informants' citations) and informal rules (37.74%) among actors with significant local ecological knowledge (LEK) in resource use, was identified in a 70.27% of the cases. Principal component analysis demonstrated five strong correlations of enabling or conflicting interactions within the VRK framework that merit close consideration for a meaningful participatory conservation strategy of both biodiversity and cultural diversity in a key hotspot. Our findings contribute to a better understanding of the socioecological context of the Mt. Hermon ecosystem and to orient decision making for effective management and conservation planning in the region and beyond.

Keywords VRK Framework · Biocultural Approach · Conservation · Local Ecological Knowledge · Biodiversity · Mount Hermon · Lebanon

Introduction

Biocultural approaches to conservation focus on the interdependence of biological diversity¹ and cultural heritage (UNESCO-SCBD, 2014; Gavin et al., 2015; Wengerd & Gilmore, 2022; Reyes-García et al., 2023). Conservation of biocultural diversity secures community participation in environmental governance and supports both conservation and innovation in knowledge, practices, and technologies in line with cultural values (Bridgewater & Rotherham, 2019; IPBES, 2019; Wheeler & Root-Bernstein, 2020). Ample evidence illustrates the significant contributions of indigenous people and local communities to ecosystem management and creation of knowledge based on the diverse values

¹ The Convention on Biological Diversity (CBD) defines biocultural diversity as biological diversity, cultural diversity, and the link between them (CBD, 2016, 2018).

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of nature (Brondízio et al., 2021; Azzopardi et al., 2022). Nevertheless, the practices of local communities are often poorly integrated in most conservation contexts or not fully recognized by policy makers (Mishra et al., 2017; Montgomery et al., 2020; Brondízio et al., 2021), as is the case in Lebanon (Plieninger et al., 2023).

The Values, Rules, and Knowledge (VRK) framework, originally employed in climate change adaptation research as well as by the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), enables analysis of decision making options within a specific context (Díaz et al., 2015; Gorddard et al., 2016; Colloff et al., 2017) and facilitates their assessment, including trade-offs to create and limit decisions that are applicable and feasible in a given decision context (Gorddard et al., 2016; Kirk & Craddock-Henry, 2022; Topp et al., 2022; Plieninger et al., 2023). The framework highlights key roles to meet biodiversity conservation and sustainable development goals (Prober et al., 2017; Hill et al., 2019; Oloriz & Parlee, 2020; Horcea-Milcu et al., 2022; Topp et al., 2022). However, many conservation efforts still lack input from impacted communities' perceptions of their ecosystems and resources (Funtowicz & Ravetz, 1991; Hill et al., 2019; Lomba et al., 2020; Wengerd & Gilmore, 2022). Thus, using the VRK framework to reframe conservation contexts in key biodiversity areas such as the Mediterranean Basin, in this case Mt. Hermon in Lebanon, offers an opportunity to reconcile a dichotomy between humans and the environment (Fig. 1).

In the VRK framework, values are defined as ‘... importance, worth or usefulness,’ as well as ‘principles or moral duties’ related to nature and its benefits to people to achieve a good quality of life (Díaz et al., 2015). Given the lack of an all-encompassing approach for the integration of nature value pluralism in environmental policy and decision-making, IPBES acknowledges three types of values: instrumental (“the value of objects, both physical objects and abstract objects, not as ends-in-themselves, but as means of achieving something else”), intrinsic (the inherent worth given by a society to nature as an end in itself, independent of any clear human utilitarian purpose), and relational (“preferences, principles, and virtues about human-nature relationships”) (Díaz et al., 2015; Arias-Arévalo et al., 2017; Chan et al., 2018; O’Connor & Kenter, 2019; Rawluk et al., 2019; Isacs et al., 2022; and also ipbes.net/glossary-tag/instrumental-value#).

The second key element of the VRK framework are rules that represent state or customary legislations, management arrangements, conservation agreements, and informal rules including traditional norms related to natural resource use and perception with a high potential for co-management options and culturally embedded adaptation alternatives (Cebrián-Piqueras et al., 2020). The third element is

knowledge, conceived in biocultural conservation as the cumulative result of trial and error in response to social and environmental changes, including climatic, and the associated ecological and socioeconomic challenges that they entail across generations, derived from local practices, observations, traditions, and experiences that shape perceptions of nature and its contributions to people (Ramos et al., 2016; Sterling et al., 2017; Williams et al., 2017; Cebrián-Piqueras et al., 2020; Wheeler & Root-Bernstein, 2020).

In Lebanon, despite some efforts to integrate the biocultural approach in national conservation initiatives, the role of local communities in ecosystem stewardship is understudied and marginalized. The concept of Hima², a pre-Islamic traditional local communitarian conservation system honored in the Koran, particularly practiced by Arab populations in the Middle East and neighboring areas, is recognized internationally (Kilani et al., 2007) and now reemerging nationally. Hima is an example of traditional biocultural conservation that integrates nature protection with human well-being (Alliance for Mediterranean Nature and Culture/MAVA, 2023). Since the 2000s, the system has been revitalized due to major political, economic, and social changes in the Levant and the Arabian Peninsula (Gari, 2006). It has been encouraged by scientists, governments, and NGOs in the region, and is officially one of the biodiversity and land conservation categories of Lebanon, Saudi Arabia, Syria, and Yemen, even if rarely translated into real or effective policies (MoE, 2006; Alliance for Mediterranean Nature and Culture/MAVA, 2023). The only previous study concerning conservation using the VRK framework in Lebanon (Plieninger et al., 2023), was part of a broader Mediterranean comparative analysis.

The Study Site

Situated in the Levant, Mount Hermon³ massif forms a mountain cluster constituting the southern end of the Anti-Lebanon Mountain Range in the eastern part of the country with an area of about 1,000 km² (Figs. 1 and 2). Karstic geological formations of dominant Jurassic limestone and occasional basaltic veins broken by faults and solution channels constitute the main topographic features. While its summit spans the border between Lebanon and Syria at 2,814 m.a.s.l., the southern slopes extend to the Israeli-occupied portion of the Golan Heights. The climate is typically Mediterranean characterized by hot dry summers and cold winters. The mountain receives a good deal of precipitation with snow

² In Arabic literally “a protected place” or “protected area” to which access is forbidden in certain periods, in order to allow regeneration of vegetation, particularly rangelands.

³ The name “Hermon” stems from the Semitic root “*hrm*” (sacred mountain).

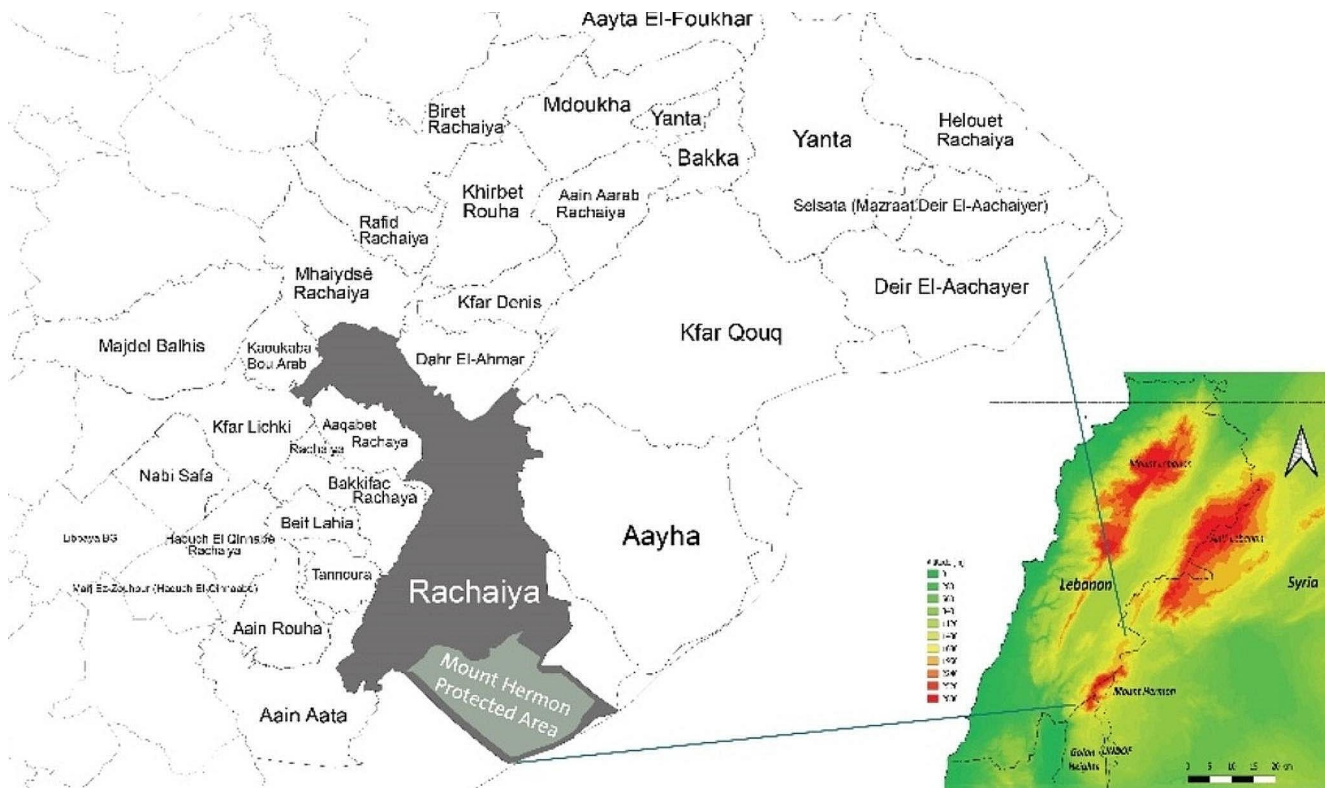


Fig. 1 Map of the study area, the town of Rachaiya and Mount Hermon Nature Reserve (in grey), and surrounding villages of the District of Rachaiya on the western slopes of Mount Hermon, Lebanon



Fig. 2 A view of Mount Hermon, Lebanon

covering its peaks for a few months (December to May) in recent decades and feeding many springs and streams that converge into the Jordan River. The climate near the summit is Oro-Mediterranean, with monthly average temperatures at the highest inhabited areas (1,640 m.a.s.l.) ranging between 3.3°C in January and 21.7°C in August, with an annual average of 12.9° C. Average monthly rainfall is in the range of 0.9 mm in August and 300.3 mm in January, and an annual average of about 1,352.8 mm (MoE/UNHCR/unicef/

UNDP, 2020), which is very high compared to the dryer and hotter surrounding areas to the East and South-East. These very particular bioclimatic characteristics make it a biological refuge zone with very particular agro-pastoral practices.

Mt. Hermon is globally recognized as a biodiversity hotspot (CEPF, 2017), characterized by a large area of biophysical environments hosting unique and rich biodiversity. It is classified as one of the Important Plant Areas of Lebanon according to Plantlife International (2004), due to its floristic richness and high number of naturally rare and endemic species (Arnold et al., 2015; Bou Dagher-Kharrat et al., 2018; Zein, 2020). A mosaic structure of habitats extends along elevational gradients, each featuring a rich and specific pattern that is essential to understand in the design of effective management and conservation plans. These habitats are comprised of thickets of *Crataegus azarolus*, woodlands of *Quercus coccifera*, *Quercus infectoria*, and *Quercus look*, along with rocky shrublands, grasslands, and woodlands of *Juniperus excels*. They extend over four altitudinal belts: Oro-Mediterranean (2,800 to 2,000 m), Montane-Mediterranean (2,000 to 1,600 m), Supra-Mediterranean (1,600 to 1,250 m), and Meso-Mediterranean (1,250 to 1,000 m) (Zein, 2020). These habitats harbour plant species (330 identified to date), belonging to 42 botanical families, with Fabaceae, Asteraceae, Poaceae, Lamiaceae and Apiaceae

representing 61% of the total. Among these species are 18 narrow endemics and some crop wild relatives (CWR) of grains and legumes that represent a high-value genetic resource for global food security, the local economy, and local livelihoods. Recent studies reported high localization and abundance of *Triticum* species (*T. dicoccoides*, *T. boeoticum*, *T. timopheevii* subsp. *Armeniacum*), *Hordeum spontaneum*, and *Lens culinaris* subsp. *Orientalis*, among other CWR (Sayde et al., 2023, 2024). The distribution of species has a hump shaped pattern between species richness and altitudes, with an increasing proportion of endemic species towards the summit (Levin et al., 2007; Zein, 2020). Large mammals and reptiles are also an important part of the rich biodiversity. Bird species, some of which are globally threatened or have limited distributions, make Mt. Hermon an Important Bird Area (CEPF, 2017, 2019).

However, two large afforestation sites were planted in the 1960s by the Ministry of Agriculture at about 1,000–1,550 m. Although they are composed of a mix of conifers, i.e., *Cupressus sempervirens*, *Pinus brutia*, and *Cedrus libani*, that are not native to Mt. Hermon, these sites may still provide complementary conservation services to those offered by the native trees and are partially compatible with local populations uses (Castro-Díez et al., 2019; Reisman-Berman et al., 2019).

Historical Background

Long historical interactions of humans on Mt. Hermon has left widespread patches of cultivated fields, mostly located around villages or on plateaux at altitudes up to 1,550 m. Stone walls enclosing fields and supporting terraces at steeper slopes prone to erosion show centuries of traditional practices contributing to soil fertility maintenance. Cultivated crops include rain-fed cereals (e.g., barley, wheat) and legumes (e.g., chickpeas, lentils) as well as crop landraces characterised by high adaptive capacities to local environmental and climatic conditions (Sayde et al., 2023, 2024). Grapevines, fruit trees (e.g., almonds, cherries, walnuts), and olive groves grown on ancient terraces are among the main crops providing stability to the overall socio-ecological system.

At the same time, Mt. Hermon holds a rich assemblage of cultural and spiritual values that signifies long standing relationships between humans and the environment (Aliquot, 2008; UNESCO, 2019; Haddad, 2021). Several well-preserved archaeological sites, ancient sanctuaries, and temples are spread across the mountain slopes and surrounding villages (Aliquot, 2008; Haddad, 2021). The isolated heights of the massif have from ancient times attracted worshippers

of different confessions. Beyond the Bible⁴, one of the earliest references to Mt. Hermon is in the Mesopotamian Epic of Gilgamesh. The wealth of antiquities studied by archeologists and scholars are reflected in the confessional scriptures of Canaanites, Phoenicians, and Assyrians, as well as the many Greek and Roman temples, rural shrines, tombs, and ancient settlements (Aliquot, 2008). Moreover, the high number of Roman sanctuaries indicate continuous settlement during the first three centuries AD (Aliquot, 2008).

The architectural features of traditional villages and towns found at field boundaries and gentle slopes also characterize the cultural heritage of Mt. Hermon (Figs. 2 and 3). Natural stones are used to construct elaborate walls and roof tiles. These villages and towns have now expanded through urbanization and introduction of road networks and infrastructures as well as a range of activities that are often of questionable sustainability and resilience.

Today, the slopes of Mt. Hermon are mainly inhabited by traditional Lebanese communities in 26 towns and villages in the territorial division of Rachaiya District (485 km²). The capital town, Rachaiya, dates back to at least the seventeenth century and testifies to the cultural value of the contemporary history of Lebanon. At the Citadel of Independence, French mandate authorities held early national leaders of the country captive during the 1943 rebellion, which triggered the country's independence on November 22 of that year. The remarkable spread of many ancient temples and archaeological sites across the villages of Ain Hircha, Yanta, Bakka, Kfar Qouq, Deir El-Aachayer, and Kfarmeshki situated in a rapidly changed landscape, affirm the impressive cultural heritage of the area and urgent need for conservation and protection measures.

According to recent estimates by the Lebanese Republic Central Administration of Statistics (CAS, 2020), the

⁴ For example, Psalm 42:6, “*O my God, my soul is cast down within me: therefore will I remember thee from the land of Jordan, and of the Hermonites, from the hill Mizar*”, and Psalm 133:1–3, “*Behold, how good and how pleasant it is for brethren to dwell together in unity! It is like the precious oil upon the head, running down on the beard, the beard of Aaron, running down on the edge of his garments. It is like the dew of Hermon*” (New King James Version, 1982). It is also mentioned in the apocryphal Book of Enoch as the place where the Grigori (“Watcher”) class of fallen angels descended to Earth and as the northwestern limit of Israelite conquest under Moses and Joshua. Despite continuing controversy regarding the exact location of transfiguration of Jesus Christ, Mt. Hermon is believed to be a primary candidate by some scholars and local communities (Sybrowsky, 2003; Waheeb, 2019; Haddad, 2021). Christian, Muslim, and Druze communities across Lebanon still identify strong spiritual connections to the mountain, such as the feast of the Transfiguration on August 6, and year round worship at the caves and maqams of the Sheikh el-Fadel (Mohamed Abi Hilal), a remarkable Druze ascetic savant, on the hilltops of Kawkaba and Ain Aata villages, and the Saint George (El Kheder) maqam in Ain Arab (Haddad, 2021; Ministry of Tourism, visit-lebanon.org).

Fig. 3 View of Rachaiya town and stone walls in traditional animal barns



population of Rachaiya District is about 33,800 (including some Syrian and Palestinian refugees) and is composed of Druze (42%), Sunni Muslims (36%), Christians (21%), and a Shia minority (1%). These religious groups persist, despite of repeated historic outbreaks of sectarian hostilities (Traboulsi, 2007). Females and males represent almost equal shares (50.2% and 49.8%, respectively) (CAS, 2020). The age group 19–64 years constitutes 58.6% of the population, the younger group of fewer than 18 years old 28.6%, and the remaining group of 65+ years old 12.9%. With respect to socioeconomic status, 80.5% of households are classified as between poor and average, 16% as poor to very poor, and 3.5% as wealthy or financially well-off, while the country's overall proportions are 67.5%, 26.3%, and 6.2%, respectively. Employment is estimated at 36.4%, lower than that of the national average (43.3%). The illiteracy rate is higher for women (14.9%) than for men (7%), and for individuals aged 10 years is above 11%, one of the highest in Lebanon's average at 7.4%.

The economy is based on services and industries that are the major employers for both women (90.4% and 7.3% respectively) and men (68.1% and 21.1%, respectively) with the majority of working individuals based in the capital of Beirut and its suburbs. Agriculture represents a sector for local economy and employment for only 2.2% and 10.8% of working women and of men, respectively, who remain in their home villages and towns (Bassaoud & Sadiddin, 2019).

Like most parts of the Mediterranean, Mt. Hermon has been subject to several millennia of continuous anthropogenic pressures ranging from unsustainable to sustainable resource exploitation. Timber logging, firewood collection, grazing, harvesting non-timber forest products (NTFPs), and hunting represent significant pressures and risks. Agricultural expansion, especially recent intensive agriculture and the introduction of new fast-growing crops, has led to rapid habitat loss and fragmentation. In recent decades, climate change has become a primary threat to the ecosystem and livelihoods (Smiatek & Kunstmann, 2015; Kaniewski et al., 2017). ERA5, the fifth generation the European

Medium-Range Weather Forecasts (ECMWF) atmospheric analysis of global climate, recorded an increase of 1.5°C in temperatures between 1979 and 2023 in Mt. Hermon (meteoblue.com), reflecting serious stress on water, soil, and land exacerbated by population growth and urbanization due to the influx of Syrian refugees in the region. In addition, hydrological simulations predict a 2.6°C increase in annual mean temperature and a decrease in precipitation of 20% by 2100, inevitably increasing pressure on natural resources and disproportionately impacting the underprivileged (Smiatek & Kunstmann, 2015).

In 2020, the Hermon Nature Reserve (12.6 km²) was created in response to national and international recognition of the importance of its ecosystem (Law 202 dated 30/12/2020) (Center for Research and Studies in Legal Information, Lebanese University). The Reserve is managed under law No. 130 (2019) that regulates protection and management of biodiversity and land use, and prohibits grazing, mining, water or soil extraction, setting fires, hunting, waste dumping, construction and all other activities that may affect the reserve negatively. The Reserve represents a very promising initiative to meet conservation needs and ensure the regeneration of the unique species and habitats of the mountain ecosystem. Nevertheless, the Reserve's focus on conservation, even often favorable to greater degrees of biodiversity or key biodiversities, does not definitively assure local communities livelihoods and sustainable practices. Thus, a biocultural approach for conservation becomes an explicit requirement.

Methods

Data Collection

We identified informants in the town of Rachaiya, on the basis of age (≥ 18 years), and length of residence and familiarity with the region. We interviewed a total of 126 informants (71 males (56.35%) and 55 females (43.65%)), including members of the municipality council and

governmental institutions, NGOs, farmers, beekeepers, herders, students, military officers, educators, housewives, and a few retired and unemployed individuals, using in-person semi-structured questionnaires⁵. Interviews were conducted in Arabic during September 2022 and April 2023. The average age was 40.11 years with the youngest informant 19 and the oldest 73 years old (Fig. 4). More than half of the informants ($n=81$, 64.29%) had university or higher degrees, 29 (23.02%) had secondary schooling and the remainder ($n=16$, 12.69%) had primary, intermediate, or no schooling.

Interviews collected socio-demographic data such as age, gender and profession, and open-ended questions addressed three themes: (1) Perceptions on the importance and values of Mt. Hermon to individuals and society; (2) Knowledge and experience with the ecosystem and biodiversity, and (3) Formal and informal rules of land use, practices, and management, following Gorddard et al. (2016), Oloriz and Parlee (2020), and Topp et al. (2022). Interview duration varied between 15 and 30 min. Prior to the interviews, we explained the purpose and background of our research and provided a detailed explanation of biocultural conservation contexts and the VRK framework, and obtained informants' verbal consent to participate. All informants' names were coded.

Content Analysis

We translated informants' responses into English and then coded them according to the VRK framework: values were categorized as “subjective intrinsic,” “instrumental,” or “relational” (Chan et al., 2016; Arias-Arévalo et al., 2017; 2018) (Table 1). Rules were categorized into: (i) formal rules that included national legislation, local authority arrangements, and conservation agreements; and (ii) informal rules consisting of implicit customary practices, relations, habits, and rituals (Table 2). For knowledge acquisition, we used: (i) local ecological knowledge comprising to acquired knowledge through cultural settings, traditions, daily experiences and observations; (ii) scientific knowledge generated by scholars at universities and research institutions that permeates to local informants; and (iii) technical knowledge that is associated with specialized technology and expertise related to natural resource management and environmental protection (Table 3). Post coding, we used Statistical Package for Social Sciences (SPSS), version 24, 2016 for both qualitative and statistical descriptive analysis and Principal Component Analysis (PCA). Citations not clearly attributed to any of the categories were not considered. The PCA was used to form groups of abstract variables (principal components), which were weighted in linear combinations of the original variables (VRK categories). The components were created to maximize the variance explained by each

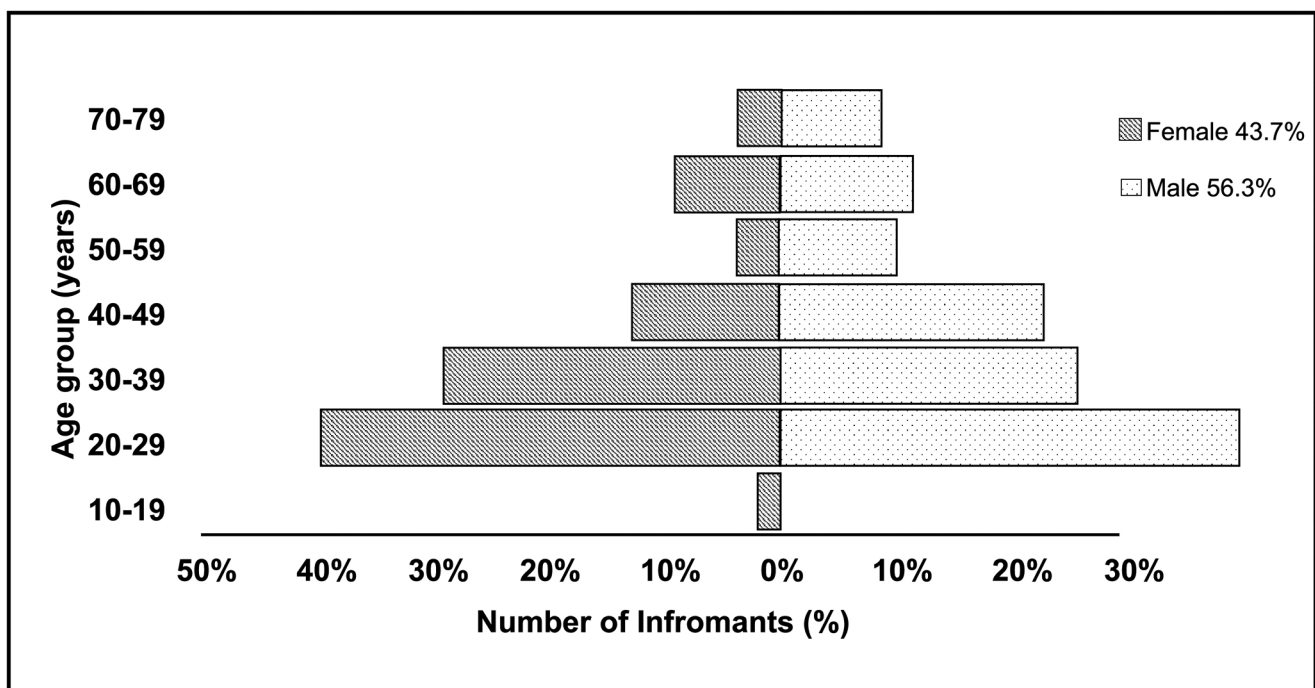


Fig. 4 Age groups of the informants of the study

⁵ A draft questionnaire was piloted and revised before the field survey.

component and examine potential relationships among dependent variables (Hoshino et al., 2017; Topp et al., 2022). Eigenvalue ≥ 1 in scree plot was used as a default cut-off value to determine the number of principle components to be retained.

Results

Values

We recorded a total of 1,497 citations of a diverse array of instrumental, ‘subjective’ intrinsic, and relational values (Table 1). Instrumental values such as water through snow melt and rain, tourism and recreational activities, bee keeping, and land and soil for crop production scored 114, 103, 88 and 85 citations, respectively, were the most frequently expressed ($n=761$, 50.84%), followed by relational (627, 41.88%) and intrinsic values (109, 7.28%). Freshwater provisioning for household use and irrigation was perceived as most fundamental for livelihoods and well-being. Ecotourism and religious tourism were also highly rated for job creation and promoting exports of local traditional products, contributing to both local and socioeconomic security and prosperity. Informants also valued agriculture and food systems (livestock production, grazing, and bee keeping), collectively scoring 242 citations and 31.80% of instrumental values. Informants explained that recent revitalized attention to these sectors was due to the current severe economic

crises in Lebanon and high inflation of food prices, together with a decline in purchasing power for imports, which all significantly increase the demand for food and agricultural production. Interestingly, CO₂ uptake and temperature regulation were cited among important instrumental values ($n=98$, 12.88%). Informants described observed snow reduction and increase in temperatures while stressing the need for effective communication strategies on climate change impact and identification of rigorous mitigation strategies.

Some informants emphasized the importance of firewood collection in light of severe economic circumstances and a surge in fuel prices, although it, overall, scored fewer citations ($n=42$, 5.52%). In addition, some of the older informants cited stone collection from fields after preparatory ploughing for use in sustainable field terracing, soil stabilization, boarding planted trees, and as a fencing material, and farm walls.

Diverse subtypes of relational values were cited ($n=627$, 41.72%) (Table 1) with a strong emphasis on social identity ($n=101$, 16.11%), sense of place ($n=94$, 14.99%), spiritual way of life ($n=85$, 13.56%), and family ties ($n=79$, 12.60%) (Table 1). For intrinsic values, 109 informants expressed strong support for the right of Mt. Hermon with all its components to exist irrespective of human direct or indirect use and other types of values. At the same time, some ($n=19$, 15.08% of total informants) considered humans an inherent part of the mountain system responsible for its conservation.

Table 1 Community perception of Mt. Hermon values

Value type	No. and frequency of citations	Subtypes of cited values (No. of citations)
Instrumental	– 761 (50.84%)	<ul style="list-style-type: none"> – Land for construction (35) – Land and soil for crop production (85) – Climate change mitigation through uptake of CO₂ (51) – Water source through snow melt and rain (114) – Regulation of local temperature (47) – Bee keeping (88) – Grazing (69) – Hunting for food (9) – Collecting wild food plants (50) – Collecting medicinal plants (48) – Fire wood (42) – Construction material (20) – Tourism and recreational activities (religious tourism, ecotourism, hiking, food, hunting) (103)
Subjective intrinsic	– 109 (7.28%)	<ul style="list-style-type: none"> – Nature’s right to exist for its natural and spiritual value regardless of any human experience (109)
Relational	– 627 (41.88%)	<ul style="list-style-type: none"> – Sensing wildlife & nature (47) – Cultural knowledge (53) – Interdependency in farming (53) – Moral duty and concern for nature (60) – Family ties (79) – Recreation & leisure (55) – Sense of place (94) – Social identity (101) – Spiritual way of life (85)

Table 2 Rules applied in Mt. Hermon

Rules type	No. and frequency of citations	Subtypes (No. of citations)
Formal	– 165 (62.26%)	– National legislations (ministries and local authorities) (84) – Local legislations (municipalities) (67) – Land use agreements (4) – Conservation agreements (10)
Informal	– 100 (37.74%)	– Customs, habit, and neighbor and family relations (83) – Religious and spiritual rules (17)

Table 3 Knowledge applied in Mt. Hermon

Knowledge type	No. and frequency of citations	Subtypes of knowledge system
Local ecological	– 104 (70.27%)	– Knowledge held by a specific group of people about local ecosystems. This knowledge is derived from human - nature interactions through daily experiences, history, cultural beliefs, practices and traditions
Technical	– 35 (23.65%)	– Specialized knowledge and expertise required to perform specific tasks and use specific technology and provide training
Scientific	– 9 (6.08%)	– Knowledge derived from scientific research, exchange with scholars

Rules

Informants articulated a mixture of formal ($n = 165$, 62.26%) and informal rules ($n = 100$, 37.74%) that govern access and resource use (Table 2). For example, they expressed high awareness of Ministry of Interior legislations regulating construction and prohibiting logging, waste dumping, and use of pesticides. Nevertheless, noncompliance was cited as a common practice in publicly owned spaces usually referred to as “Macha’a”⁶. For instance, extensive firewood logging (described by some informants ($n = 9$, 7.14%) as an environmental crime) is widely practiced despite local authorities’ efforts to enforce the law. Informants attributed this to inadequacy of law enforcement and lack of application of either sanctions or incentives. Contrary to this situation, most informants reported full compliance with formal legislations on privately owned lands.

Informants reported the nonexistence of any formal rules to govern access to public pastures that has led to grazing and foraging practiced freely in a variety of publicly owned spaces according to available resources. Traditionally, informal rules to ensure equitable access and resource use were historically successful and sustainable, usually comprising a guard recruited by a local committee to enforce access fees per head of cattle, on the access of common pasture, and a religious leader to arbitrate violations or resolve disputes.

In the case of privately owned lands, informal arrangements with landowners in return for milk or other products allow access to fields post harvesting, which contributes to their fertility, are still followed. With respect to bee keeping, informants reported no rules of any kind. Bee keepers benefit from open access use of public spaces despite a reported limitation in bee foraging availability, according to some informants, who explained that the current number of hives

(15,000 in Rachaiya town alone), which require a forage area of about 1,000 m²/25 hives, is too high to support good colony survival and development, adversely affecting yields and quality of honey. In addition, recent climate changes including increased temperatures, shifts in precipitation patterns, heat waves, and decreased snow also negatively affect mountain blossoms. A key member of a local NGO told us about the efforts of the organization to promote planting aromatic plants such as rosemary, lavender, oregano, and saliva known to attract both bumblebees and honeybees aiming to enhance forage capacity.

Informants also described general compliance with informal rules relating to social ethical and religious values in connection with wildlife protection, equitable access to, and use of natural resources in order to prohibit overexploitation and promote stewardship and sustainable practices.

Knowledge

There were 148 citations to knowledge underpinning informants’ values, practices, and cultural perspectives (Table 3), with LEK most frequently cited ($n = 104$, 70.27%), followed by technical knowledge ($n = 35$, 23.65%), and scientific knowledge ($n = 9$, 6.08%). Intercropping, crop rotation, cover cropping, land terracing, traditional organic composting, and integrated crop-animal farming as well irrigation and rain harvesting practices were among the most frequent examples of LEK. Informants also knew about different plant traits and their capacities to support beekeeping, and awareness of bee diseases and threats linked to the use of pesticides. They also cited traditional knowledge of pasture quality and properties of forage plants along with their impact on livestock health and production of meat and milk, and the properties and availability of edible and medicinal plants and their uses.

⁶ Open access land under the authority of the municipality of Rachaiya.

Informants indicated knowledge of firewood types, their heating capacity, and charcoal production, as well as local climatic conditions, patterns, and variability and their impacts on agricultural activities, and indicated some adaptive practices. However, it was generally noted that much of the detailed knowledge was provided by farmers, beekeepers, and active NGO members who are presently involved in nature/environment related activities. These informants particularly emphasized that much of the local knowledge is not documented but rather orally transmitted by older generations, which exposes it to the risk of loss.

Informants acknowledged limited technical knowledge pertaining to certain sustainable agriculture practices, bee keeping, food safety, and ecotourism, which was only occasionally applied. However, this knowledge was often acquired through different capacity building programs initiated by governmental bodies and NGOs.

PCA Grouping of Perception

We used PCA, which reduces data dimensionality and determines the most effective variables (loadings) in each association of variables to identify possible underlying associations among the categories of Values, Rules, and Knowledge (Engen et al., 2019). This transformation allows the first component to reflect as high a variance as possible accounting for much of the variability in the data, and each succeeding component in turn has the highest variance

possible under the constraint to be orthogonal to (uncorrelated with) the preceding components. This can help to group perceptions of informants and to reflect interactions (association) among the subtypes of values, rules, and knowledge. High loading subtypes (variables) may drive responses in the principal component created by a specific association of the variables, which may in turn, provide better insight on cultural relevance, and more meaningful participation of the community in conservation efforts.

The PCA output resulted in a scree plot of eight components and eigenvalues associated with each component (Fig. 5). The cut-off eigenvalues ≥ 1 and cumulative extraction sums of squared loadings (%) suggested the choice of the first 5 components that can explain 70.77% of the information in the original 8 variables of societal VRK perspectives (Table 4). The factor loading value above 0.6 was deemed important, and the values equal or larger than 0.6 are highlighted in bold in Table 4. Each of the obtained 5 components is strongly loaded by different associations between VRK categories of community perception. Principle Component 1 shows a strong positive correlation between informal rules, formal rules and technical knowledge of the original variables. As for PC2, a strong negative correlation between ecological knowledge and scientific knowledge is apparent. A similar negative strong correlation between instrumental values and formal rules is found in PC3. Also, strong positive correlations are shown between technical

Fig. 5 Scree plot of PCA and eigenvalues of components

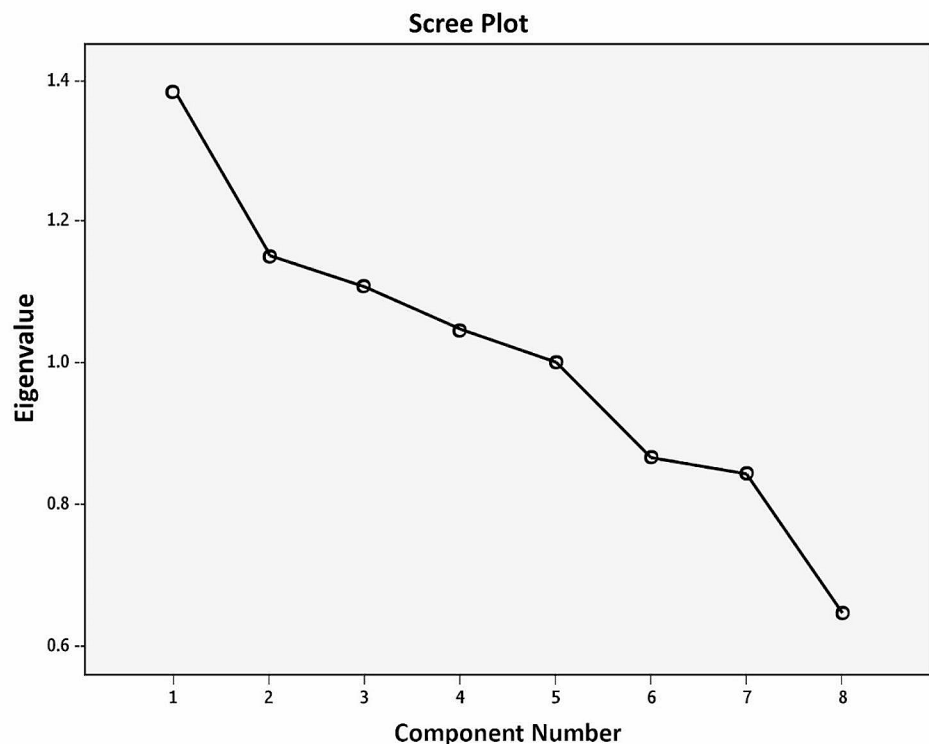


Table 4 Rotated component matrix

VRK elements	PC1	PC2	PC3	PC4	PC5
Informal Rules	0.736			−0.166	
Technical Knowledge	0.636	−0.197		0.469	0.138
Ecological Knowledge	−0.123	0.808	0.147		0.267
Scientific Knowledge	−0.189	−0.669	0.146		0.451
Instrumental Values	0.259		0.796	−0.145	
Formal Rules	0.337		−0.660	−0.115	0.118
Relational Values				0.897	
Intrinsic Value			−0.108		0.884

knowledge and relational values in PC4 and between scientific knowledge and intrinsic values in PC5.

Discussion

Our findings allow a better understanding of the socioecological context and possible underlying associations among values, rules, and knowledge of community perceptions of Mt. Hermon. The five different dimensions (PCs) in PCA output show strong loadings by different interactions among the VRK subtypes reflecting different interactions in the groups of perceptions (PCs) (Table 4). Such interactions can constrain or enable decision making and create a balance including trade-offs in the conservation strategies (Solomonsz et al., 2021; Plieninger et al., 2022; Topp et al., 2022).

Biocultural Conservation

Mt. Hermon features a mosaic of natural, human dominated, and mixed socioecological landscapes where a diversity of human activities and different cultural elements are evident through a diverse array of community expressed values, knowledge and rules associated with the mountain ecosystem (Stepp et al., 2005; Speed et al., 2012; Tenerelli et al., 2016; Schirpke et al., 2020). For example, freshwater provisioning, religious tourism, and sense of social identity and place were noted by informants among factors reflecting the interconnectedness and values of the mountain (Table 1). Deforestation and the subsequent transformation into agricultural land, terraced fields, pasture fields, rain harvesting, along with ancient archeological elements represent some examples of this influence (Williams et al., 2020; Aziz et al., 2022; Chu et al., 2022). Despite the archaeological evidence of a long history of spirituality associated with Mt. Hermon (Verschuuren et al., 2021), recent increasing use of modern technology, replacement of natural vegetation with vulnerable monocropped and intensively cultivated fields, and intensive logging along with urbanization and other unsustainable practices, indicate a serious erosion of the

valuable socioecological elements of the mountain territory. Therefore, the development of a new integrated conservation and management approach that is not limited to natural ecosystem elements and wildlife, but rather, integrates both the biodiversity and cultural diversity of Mt. Hermon is required. Such an approach can lay the foundations for effective conservation measures while ensuring the welfare of the local people (Verschuuren et al., 2021; Esgalhado et al., 2021; Plieninger et al., 2023).

VRK Perception and Interplay

The VRK we have identified in our study demonstrate various intersecting or conflicting social perspectives associated with the Mt. Hermon ecosystem. The wide range of identified subtypes of instrumental, ‘subjective’ intrinsic values and relational values, reveals the importance and multi-functionality of the mountain. These values have evolved through people’s adaptive capacity to manage environmental and climate conditions and socioeconomic pressures characterizing the Mediterranean region. Instrumental values such as the provisioning of fresh water, tourism, agriculture, bee keeping, pastures, and firewood present fundamental aspects of community livelihoods and socioeconomic security. The relatively high number of informant citations of the value of Mt. Hermon in CO₂ uptake and temperature regulation indicate important understanding of climate change. This can be partially related to the fact that more than half the informants ($n = 67$, 53.17%) had university or higher education levels often associated with high awareness (Simpson et al., 2021; Chimi et al., 2020). It may also be associated with a high prevalence of LEK ($n = 104$, 70.27%) relating to climate variability and its impacts (Coll-off et al., 2017).

Relational values, particularly the sense of social identity and place (Arias-Arévalo et al., 2017; Himes & Muraca, 2018) confirm the vital role of biocultural relational values in conservation decision making and high potential for care and stewardship actions of the community towards the mountain (Mattijssen et al., 2020; Arias-Arévalo et al., 2018; Uehara et al., 2022). This ensures the welfare of both

the ecosystem and people. As found in previous studies in this area (Uehara et al., 2022; Yuliani et al., 2022), these relational values are closely interrelated to both instrumental and intrinsic values that highlight the relevance of value plurality in biocultural conservation contexts. On the other hand, the perceived values entail major contrasting interrelations particularly evident between the instrumental and intrinsic values of the mountain. This is clearly exemplified in the provisioning of fresh water and land for crop production (instrumental values) that implicitly assumes that what matters is to serve the livelihoods and wellbeing of communities and not the intrinsic value of the mountain itself. This and other cases in the literature strongly support the increasing importance of value plurality and the need to consider this perspective in conservation decision making (Arias-Arévalo et al., 2017; Himes & Muraca, 2018; Schmitt et al., 2022). Therefore, adopting value pluralism and moving beyond narrow instrumental values within the multi-functionality context of Mt. Hermon have the potential to better develop efficient and mutually accepted conservation decisions (Leventon et al., 2021; Borrie & Armatas, 2022; Schmitt et al., 2022). Again, the case of eco and religious tourism perceived among the top instrumental values (Table 1) illustrates that community members can be highly motivated by initiatives that provide high socioeconomic benefits while maintaining both relational and intrinsic values of the mountain.

The perceived co-existence of, often conflicting, formal and informal rules governing land use and practices in the mountain system reflects the role of both in the design of effective conservation decision making. Cases of conflicts and prevalent refraining of compliance of formal national legislations such as the Environment Protection Law No. 444/2002 and Forest Protection No. 558/1996, may be attributed to a discrepancy between the objectives of the authorities and the communities (Gorddard et al., 2016; Atuo et al., 2020; Yuliani et al., 2022). Thus, integration of rules is crucial for appropriate conservation decision making and the enhancement of community well beings (Williams et al., 2020; Solomonsz et al., 2021; Chu et al., 2022).

Local ecological knowledge, scoring 104 citations (70.27%), seems to be strongly prevalent in influencing the choices and practices of communities. The consideration of this knowledge in all decision-making structures and processes of the mountain management strategy and implementation is necessary. Research and case studies from the Mediterranean and beyond illustrate that a biocultural approach that is inclusive of ecological local knowledge is a vital instrument to design culturally appropriate conservation strategies (Aziz et al., 2022; Nemogá et al., 2022; Plieninger et al., 2023). For example, while technical and scientific knowledge are both necessary to develop

grazing management and pasture improvement plans, local knowledge can serve in the identification of important forage plants and their impact on production and health of livestock. Local farming systems have resulted in the development and preservation of landraces that tolerate environmental stresses including climate change. Such traditional knowledge is today receiving a worldwide attention as a vital aspect of sustainability studies (Ramos et al., 2016; Garavito-Bermúdez, 2019; Nemogá et al., 2022). However, the fact that articulated local knowledge was restricted to specific individuals or groups indicates a high risk of loss. This knowledge should be more consistently documented and promoted at local and national scales while protecting the rights and benefit sharing of the knowledge holders (Garavito-Bermúdez, 2019; Nemogá et al., 2022). To be successfully integrated into decision-making, such knowledge must be perceived as legitimate, meaning it has been produced with respect to community values, and fair treatment of opposing interests (Lopez-Maldonado & Berkes, 2017; Nemogá et al., 2022).

As shown in other studies, the evident limited perception of communities regarding technical knowledge and scientific knowledge is believed to reflect negatively on the implementation of any conservation measures (Daniel et al., 2012; Morales-Reyes et al., 2018; Wengerd & Gilmore, 2022). This highlights the need for the creation of multiple and transdisciplinary knowledge systems among different groups and actors through dialogues and inclusion (Garavito-Bermúdez, 2019; Oloriz & Parle, 2020; Topp et al., 2022; Plieninger et al., 2023).

Finally, the associations among values, rules, and knowledge of community perception reflected in the five different dimensions (components) of PCA output (Table 4) prompt a close examination aimed toward the creation of a balance including trade-offs to facilitate long term and strategic conservation decisions. As such, PC1 of PCA (Table 4) expresses the importance of the integration of informal rules along with technical knowledge in community perceptions. One example may be seen in the perceived inadequate technical knowledge on the conservation of rare and important species, such as *Cousinia hermonis* Boiss., *Erysimum verrucosum* Boiss. & Gaill, and *Euphorbia erinacea* Boiss., endemic to Mt. Hermon and the Anti-Lebanon Mountain Range (Zein, 2020) constraining the implementation of conservation legislation and rules. Supporting the diffusion of technical conservation knowledge while recognizing the importance of LEK strengthens a community's ability to innovate and apply various forms of technologies and enables interactions with rules (Kirk & Cradock-Henry, 2022). Component 2 further supports the importance of LEK and scientific knowledge and highlights the inherent interplay in the relationship of scientific and local knowledge

being created by drivers and approaches (Cebrián-Piqueras et al., 2020). Deeper understanding of how these types of knowledge influence community perceptions and values is highly relevant for the development, adoption, and diffusion of integrated knowledge system in the conservation context of Mt. Hermon (Cebrián-Piqueras et al., 2020). The strong negative correlation between instrumental values and formal rules associated with PC3 reflect perceived conflicting interactions, for example the conflict between the perceived value of firewood provisioning and the formal rules prohibiting logging most certainly impede conservation actions while adversely impacting community livelihoods. Another example is the interaction between pasture provisioning and formal zoning rules in the Law of the Hermon Nature Reserve is likely to adversely impact future herding practices. Management of such clashes of interest is crucial to achieve effective conservation and sustainable resource use (Yuliani et al., 2022). The sole high loadings of relational values in PC4 and intrinsic values in PC5 recognize that relational and intrinsic values are locally well rooted in community perceptions and can serve as key drivers of stewardship motivation and transformative behaviors (Arias-Arévalo et al., 2017; Chan et al., 2018; Yuliani et al., 2022).

Conclusion

Mt. Hermon, a cultural and biological diversity hot spot, is characterized by rich socioecological features with a strong interconnectedness between inhabitants and biophysical elements. These socioecological features prompt the need for a biocultural approach for effective conservation of interactions built through long historical processes that are fragile in the present context of accelerated global change. Community perceptions of a wide range of multiple instrumental, intrinsic, and relational values allow a better understanding of the local context of the mountain system. The compatible high prevalence of instrumental and relational values offers motivational opportunities towards local conservation stewardship and behavior transformation, while intrinsic values, even if attributed with lesser importance by informants, should not be neglected, emphasizing the need for navigation between values plurality for effective conservation and trade-offs. The five main PCs of the PCA entail grouping in the perception of VRK subtypes and require a close examination while navigating options for the creation of a balance that includes trade-offs to facilitate long term and strategic conservation decisions. Despite their importance, current conservation initiatives in the Hermon Nature Reserve and across the mountain range are mainly based on formal rules and public legislation that are solely

managed by government institutions with very little to no consultation with traditional ecological knowledge holders and practitioners. Moreover, present dominant conservation initiatives have little to no consideration of cultural values, informal rules, and LEK. Therefore, the integration of plurality and interlinkages of values, rules, and knowledge as we have shown while advocating for bottom-up approaches, could have a potentially positive impact on conservation or at least provide an important direction for research-based action that the government should consider. This approach offers opportunities for innovative capitalization on cultural aspects and meaningful participatory conservation strategies based on the long-held sustainable uses of the territory and its biocultural diversity. This can bring in higher levels of resilience to these eroding systems, a loss government institutions alone are unable to stop.

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Declarations

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