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Back to the future: rethinking socioecological systems underlying high nature value farmlands

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Farmlands are currently among the dominant uses of the land. When managed under low-input farming systems, farmlands are associated with diverse cultural and natural heritages around the world. Known in Europe as high nature value (HNV) farmlands, these agricultural landscapes and their associated farming systems evolved as tightly coupled socioecological systems, and are essential to biodiversity conservation and the delivery of ecosystem services to society. However, HNV farmlands are vulnerable to socioeconomic changes that lead to either agricultural intensification or land abandonment. We present a range of plausible future scenarios for HNV farmlands, and discuss the related management options and expected socioecological outcomes for each scenario. We then provide recommendations for policy, practice, and research on how to best ensure the socioecological viability of HNV farming systems in the future.

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The intertwined and dynamic relationship between social and ecological systems has shaped a broad range of agricultural landscapes around the world for centuries (Fischer *et al.* 2012; Plieninger and Bieling 2012). In spite of their primary functions of producing food and fiber, many of these human-created landscapes are rich in natural and/or semi-natural vegetation, and can support species and habitats – often of high conservation value – that depend on specific low-intensity farming systems (Halada *et al.* 2011; Fischer *et al.* 2012; Sutcliffe *et al.* 2015). These areas, commonly known in Europe as high nature value (HNV) farmlands, support biodiversity conservation and deliver a wide range of ecosystem services on which society depends (Plieninger and Bieling 2013; Lomba *et al.* 2014; Plieninger *et al.* 2019).

In a nutshell:

- High nature value (HNV) farmlands, where social systems and ecosystems are closely intertwined, cover a large proportion of Europe's agricultural land, and also occur in other parts of the world
- In addition to their importance for food production, HNV farmlands support biodiversity conservation and deliver multiple ecosystem services
- HNV farmlands and associated ecosystem services are threatened by both agricultural intensification and farmland abandonment
- The future of these systems could range from total loss of HNV farmlands (through abandonment or intensification) to maintenance by means of various strategies
- The future of HNV farmlands can be secured by improving social services in rural communities, designing new uses for HNV goods, and developing new business opportunities on HNV farmlands

In the European Union (EU), HNV farmlands are, like most other farmlands, maintained in part by funding from the Common Agricultural Policy (CAP) (de Snoo *et al.* 2013; Lomba *et al.* 2014). The CAP aims to support agricultural production to guarantee food security and ensure a fair standard of living for those dependent on agriculture through a system of subsidies and support programs for farmers; besides including direct payments to agriculture production, the CAP also includes financial instruments to support the environment (Pe'er *et al.* 2019). Many HNV farmlands are currently under pressure from biophysical challenges (eg remoteness, soil erosion, climate) and socioeconomic factors (eg globalization of markets and specialization of agricultural systems, rural population decline, shrinking farm incomes) (Oppermann *et al.* 2012; Plieninger and Bieling 2013; McGinlay *et al.* 2017), as well as broader political and cultural changes. Such pressures contribute to the decline of HNV farming systems through two major pathways: intensification of agricultural practices and farmland abandonment. Whereas the former pathway includes changes in farming systems that are often accompanied by a higher degree of specialization and intensified production to achieve higher yields in production landscapes (Lomba *et al.* 2014), the latter pathway is characterized by the collapse of traditional farming systems, often in remote or mountainous areas undergoing demographic declines, such as in parts of Central

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Panel 1. Diversity of high nature value (HNV) farmlands across European landscapes

HNV farmlands can be found in a variety of environments, climates, economic contexts, and farming systems, and include landscapes with high natural and semi-natural habitat cover as well as agricultural land where small crop fields are intermingled with other farmland features (eg mature trees, shrubs, scrub; linear features, such as field margins and hedges).

HNV farming systems comprise livestock-based, arable-based, permanent crop, and mixed farming systems (see Figure 1 and WebFigure 1 for examples). Livestock-based systems, such as sheep, beef cattle, and/or horses grazing rough grassland, moorland, heathland, and forest, can be found in mountainous areas throughout Europe (eg predominantly sheep and goats grazing dry grassland and *maquis* and *garrigue* scrub in Mediterranean regions; sheep, pigs, and cattle grazing on permanent pastures with dispersed tree cover, such as in the *dehesas* and *montados* in southwest Spain and Portugal). Arable-based systems are mostly confined to Mediterranean regions, with the dryland (non-irrigated) systems of Spain, Portugal, southern Italy, and Greece of particular importance. Such systems are low yielding and use fallowing (in association with livestock grazing) to maintain soil fertility and organic matter content. Permanent crop systems (such as olives, fruit, and vines) were historically a key component of Mediterranean lands, but much of this cultivation has been intensified, and today the remaining HNV systems are located in more marginal areas where farming is less specialized and intercropping (eg olives, almonds, carobs, and cereal with livestock grazing) is still practiced. Mixed HNV farming systems are typically small-scale, part-time farming involving integrated crop and livestock production, such as the *coltura promiscua* and *minifundia* approaches in Italy and central and northern Portugal, respectively.

and Eastern Europe and the Mediterranean Basin (Plieninger *et al.* 2014; Queiroz *et al.* 2014; Sutcliffe *et al.* 2015). The decline of HNV farmlands is also due in part to the failure of markets to recognize and remunerate farmers for the ecosystem services that these farmlands deliver to society. In fact, most ecosystem services provided by HNV farmlands are public or quasi-public goods (Pascual 2010), and existing public policies only partially counteract the impacts of these market failures. As a result, many of the remaining HNV farmlands are currently losing socioeconomic viability (well-being of farmers and rural communities, profitability of on- and off-farm activities, local employment) due to declining farm incomes and poor social infrastructure (ie an insufficient set of founding services and structures – such as healthcare and transportation – that support the quality of life of populations); moreover, many of these farms are owned and operated by elderly farmers, and are at risk of being converted to other farming systems or being abandoned following the retirement or death of the landowner. Such socioeconomic drivers are limiting the attractiveness to younger generations of managing HNV farmlands (McGinlay *et al.* 2017). As such, the future of HNV farmlands is highly uncertain (Fischer *et al.* 2012; Plieninger and Bieling 2013; Queiroz *et al.* 2014), as is the willingness of society to maintain them.

Here, we provide an overview of how socioeconomic and ecological dimensions contribute to and support the value of HNV farmlands and the numerous services these systems provide to society. We go beyond a discussion of the role of HNV farmlands for biodiversity conservation, which has been the primary focus of previous work on HNVs (Strohbach *et al.* 2015), and propose several plausible futures for HNV farmlands. We then discuss the implications of these scenarios for land management and the expected socioecological outcomes. Finally, we focus on a future where HNV farmlands are embraced for promising the "seeds of a good Anthropocene" (Bennett *et al.* 2016), by outlining and discussing the requirements for triggering a shift toward socially, economically, and ecologically viable HNV farmlands.

Linking biodiversity conservation and the provision of multiple ecosystem services

What are HNV farmlands?

HNV farmlands and their underlying farming systems ("HNV farming systems") are characterized by low levels of agrochemical inputs and low livestock stocking levels, minimal mechanization, and rotational use of the land. Such approaches are known to maximize use of local natural resources for agricultural production while ensuring ecosystem stewardship (Plieninger and Bieling 2013; Lomba *et al.* 2014; Strohbach *et al.* 2015). These inherently crop-rich and biodiverse HNV farming systems can be found in a variety of environments, climatic conditions, and economic contexts across Europe, and encompass livestock-based, arable-based, permanent crop, and mixed farming systems (Panel 1 and Figure 1; see WebFigure 1 for additional examples).

More than 30% of all agricultural land in the EU is considered to be HNV farmland (Oppermann *et al.* 2012), and recognition of the importance of HNV farms dates back to the 1990s (Lomba *et al.* 2014). However, similar farmlands supporting high natural and cultural values in distinct socioecological contexts exist in many rural areas worldwide. All these HNV farming systems evolved as tightly coupled socioecological systems where human interventions – such as farming practices, or the selection of particular crops and livestock breeds – have shaped (and been shaped by) local ecosystems (Lomba *et al.* 2014; Strohbach *et al.* 2015). Examples include the *satoyama* landscapes in Japan, farming systems in the Western Ghats region of India, and the Hani rice terraced landscapes in southern China (Fischer *et al.* 2012; Plieninger and Bieling 2012).

Beyond biodiversity: the wider societal value of HNV farmlands

By definition, HNV farmlands support biodiversity conservation, but they are also increasingly recognized for delivering valuable ecosystem services to wider society,

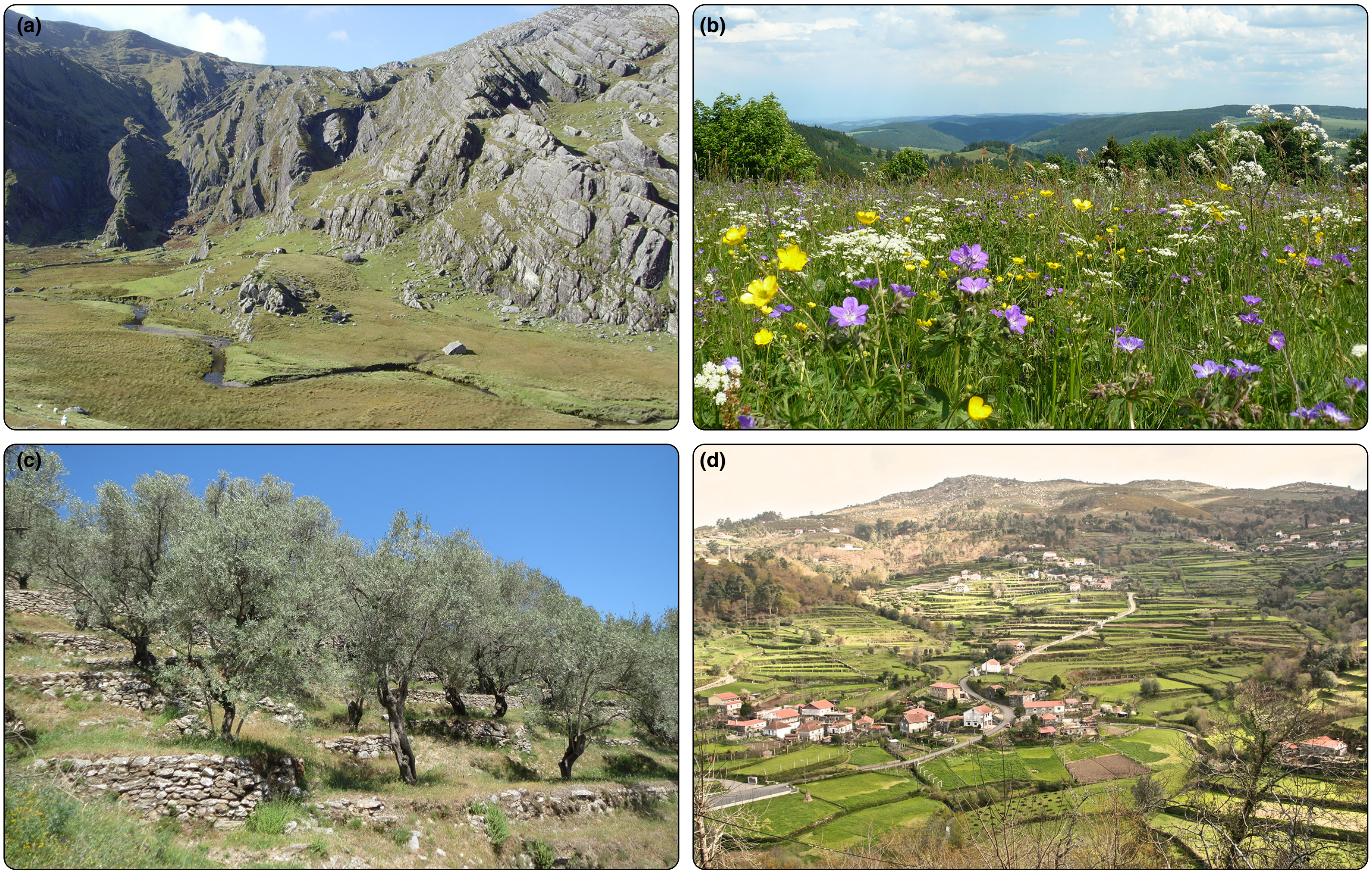

Figure 1. Diversity of high nature value (HNV) farmlands across a variety of different European landscapes. (a) Sheep-grazed, peatland-dominated farms in southwest Ireland; (b) extensively managed, species-rich upland hay meadows in the Thuringian Forest, Germany (Credit: Landschaftspflegeverband Thüringer Wald e.V.); (c) terraced olive groves on the island of Lesvos, Greece; and (d) traditional agricultural terraces maintained by small-scale mixed farming in Portugal.

thereby contributing to both sustainability and resilience in the European countryside (Plieninger and Bieling 2013; Lomba *et al.* 2014; Plieninger *et al.* 2019). Supporting functions (eg primary production, nutrient cycling, soil formation) are responsible for the sustained supply of a broad range of ecosystem services. Provisioning services include food production, fodder for livestock, and water supply, while cultural services include recreation, agro- and ecotourism, sense of place, and maintenance of cultural heritage and scenic landscapes. HNV farmlands also sustain important regulating services, including climate regulation, prevention of soil erosion, pollination, and biological control (Oppermann *et al.* 2012). Finally, the soils of HNV farmlands contain higher levels of organic carbon than the soils of non-HNV farmlands, underscoring their potential contribution to climate regulation, maintenance of soil fertility, and prevention of soil erosion and desertification (Gardi *et al.* 2016). Supporting functions (eg biodiversity maintenance), regulating services (eg erosion control, fire risk prevention) and cultural services (eg the aesthetic, historical, and recreational values of the landscape) provided by HNV farmlands are recognized and economically valued by citizens (eg in mountain ranges in the Mediterranean Basin; Bernués *et al.* 2016; Plieninger *et al.* 2019). For example, the provision of high-quality agricultural products of high economic value is linked to HNV farmlands (Bernués *et al.* 2016). These products are often labeled with "protected designation of origin (PDO)", "protected geographical indication (PGI)", or "traditional specialty guaranteed (TSG)".

Given the benefits they generate for society, HNV farmlands potentially have an important role to play in achieving multiple UN Sustainable Development Goals (SDGs; https://sustainabledevelopment.un.org/sdgs), including SDG 2 (food security, improved nutrition, and sustainable agriculture), SDG 11 (sustainable communities, including conservation of cultural and natural heritage), SDG 12 (sustainable consumption and production patterns), and SDG 15 (sustainable use of terrestrial ecosystems and halting biodiversity loss).

Alternative future scenarios for HNV farmlands

For decades, socioecological dynamics have led to reductions in the extent and condition of HNV farmlands, in turn eroding their natural and cultural heritage. Reversing such trends relies on increasing public appreciation of the ecosystem services provided by HNV farmlands and improving the financial rewards to farmers who continue to maintain them. Under current socioecological changes, five alternative scenarios – associated with different levels of management intensity and socioeconomic viability characteristics – are foreseen for HNV farmlands (Figure 2). Examining the contrasting scenarios will ultimately reveal the resulting trade-offs in terms of biodiversity conservation and ecosystem services delivery.

"Business-as-usual HNV farmlands" scenario

The "business-as-usual (BAU) HNV farmlands" scenario (Figure 2) is one in which low-intensity management practices and HNV farmlands are maintained mainly through financial support, ensuring the conservation of high levels of farmland-related biodiversity and the provision of ecosystem services (Merckx and Pereira 2015). In this scenario, HNV farmlands would continue to lack socioeconomic viability and farmers would have to rely permanently on additional financial support from public (eg rural development policies) and private sources (Figure 2). This is the most common approach for slowing the loss of HNV farmlands in the EU, and is largely dependent on economic policy instruments from the CAP (Batáry *et al.* 2015).

"Museum landscapes" scenario

An alternative scenario, that of "museum landscapes" (Figure 2), assumes that small-scale patches of HNV farmlands will be preserved in their traditional state for educational and demonstration purposes (Moreira *et al.* 2006). Although some biodiversity and ecosystem services are likely to be sustained in this scenario, the maintenance of these much smaller remnant areas of HNV farmlands that are "frozen in time" may require greater habitat-specific management and maintenance inputs, as they are no longer part of a functioning farming system. Under the "museum landscapes" scenario, HNV farmlands and their underlying socioecological systems may exhibit slightly higher socioeconomic viability (relative to the "BAU HNV farmlands" scenario), especially if there is the potential for revenue generated from visitors to these "museum landscapes". However, this comes at the cost of decoupling nature outputs from the farming system. In addition, "museum landscapes" may partially overlap with the "BAU HNV farmlands" scenario (Figure 2), showing the potential for well-preserved "BAU HNV farmlands" to be maintained in the future as "museum landscapes".

"Back-to-nature" scenario

If halting HNV farmland loss fails to become a long-term societal priority, then a "back-to-nature" scenario may be on the horizon (Figure 2). Here, agricultural management on the majority of HNV farmlands would totally or partially cease; as a result, socioeconomic viability would decline and landscapes would be transformed. Land abandonment and subsequent ecological succession are known to affect farmland biodiversity differently across geographical regions, depending on the taxa involved and the conservation focus (Queiroz *et al.* 2014). When succession pushes toward vegetation encroachment and expansion of shrub and tree cover, a regime shift takes place where HNV farmlands become less managed (or even unmanaged) ecosystems, accompanied by a loss of farmland-related species and habitats (eg species-rich grasslands) (Lomba *et al.* 2013; Plieninger *et al.* 2014). Conversely, replacement of farmlands by forest ecosystems may benefit biodiversity, such as through the return of top predators (eg lynx, bears) due to habitat regeneration or improved landscape-level connectivity (Merckx and Pereira 2015). Moreover, such "rewilded" landscapes may deliver a range of regulating ecosystem services (eg regulation of water and nutrient cycles, climate-change mitigation, soil erosion prevention) but at the expense of reducing provisioning (eg food, fiber) and cultural services (eg scenic beauty, recreation, sense of place). However, woodland expansion would also be likely to increase the risk of ecosystem disservices, such as wildfires (Moreira and Pe'er 2018). The extent to which farmland abandonment can be considered as an opportunity for rewilding is highly debated in the literature, especially with regard to European landscapes (Plieninger *et al.* 2014; Queiroz *et al.* 2014; Perino *et al.* 2019). In most approaches to rewilding, some human interventions are

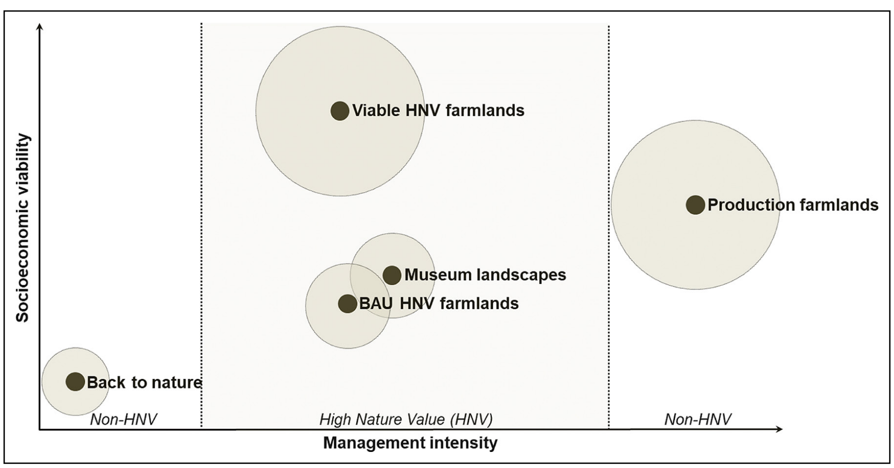

Figure 2. Conceptual illustration of alternative future scenarios for HNV farmlands. Circles represent the expected position (black circles) and respective variation (shaded circles) of each scenario along two axes representing management intensity (eg fertilizer inputs, irrigation) and socioeconomic viability (eg profitability of farm operations). A shift toward non-HNV farmlands occurs when management intensity moves above or below specific thresholds, delimited by the dotted lines. BAU: business as usual.

required to foster the maintenance of biodiversity and the provisioning of specific ecosystem services (Svenning *et al.* 2016; Perino *et al.* 2019). Furthermore, many HNV farmlands are subject to non-agriculture-related legal restrictions, which may limit the management options available to farmers; for example, a substantial proportion of European HNV farmlands are designated sites in the Natura 2000 network of the EU, a status that implies a legal commitment to preserving a favorable conservation standing only possible through active agricultural management, so that a "back-to-nature" scenario may not be legally permissible.

Figure 3. The Burren region of Ireland is an example of the pathway toward "viable HNV farmlands"; here, numerous approaches are employed to increase socioeconomic viability (www.hnvlink.eu/innovations/the-burren-ireland). Strategies include innovative results-based payments for ecosystem services that create markets for HNV public goods; connecting people and nature through place-based education programs; honoring farmers with Farming for Nature awards, which increases awareness among both farmers and wider society; and adding value to HNV farmlands through product development and ecotourism initiatives, including food trails. These and other strategies are coupled with knowledge-sharing and capacity-building programs for farmers and advisors.

"Production farmlands" scenario

In areas where biophysical conditions do not limit the growth of food production, HNV farmlands are likely to shift from the "BAU HNV farmlands" scenario to the "production farmlands" scenario (Figure 2), following the recent trend toward more specialized and intensive farming systems. Such development (eg as seen in the conversion to monoculture cropping and greater reliance on external inputs) is likely to result in higher levels of profitability associated with a small set of provisioning services if external inputs to support high food production are readily available. In the majority of cases, however, this would be expected to reduce the socioeconomic viability of the wider rural community through reductions in farm employment levels. Such a transition would involve a regime shift from HNV to non-HNV farmlands, and comes at a cost: loss of landscape heterogeneity, biodiversity decline, and erosion of several regulating and cultural ecosystem services (Gordon *et al.* 2010).

"Viable HNV farmlands" scenario

Under the "viable HNV farmlands" scenario (Figure 2), maintaining farmland biodiversity and the supply of ecosystem services will depend on increasing the socioeconomic viability of the underlying farming systems while retaining similar levels of management intensity. Pursuing socioeconomic viability will require tailored actions and operational tools to be developed, tested, and implemented at the farm level. On top of that, moving toward "viable HNV farmlands" (Figure 3) generally entails a strong commitment from society (including researchers, civil society, stakeholders, and politicians) and especially farmers, who are ultimately the most important stewards of agricultural landscapes (Garibaldi *et al.* 2017). Transition toward "viable HNV farmlands" would also require a transformational process that extends far beyond the promotion of traditional low-input farming practices (Fischer *et al.* 2012, 2017). Several of the most urgent requirements for increasing the socioeconomic viability of HNV farmlands in the future, and thereby ensuring the maintenance of their inherent social and ecological heritage, are presented in Panel 2 and addressed in the following section.

Moving toward socioecological viability of HNV farmlands

HNV farmlands are valuable assets that can aid society in addressing current and future socioecological challenges (Bennett *et al.* 2016; Fischer *et al.* 2017), but change is unavoidable, and a paradigm shift is required to ensure that the underlying socioecological systems persist and that HNV systems appeal to future generations. Such a shift entails moving from static or sectoral strategies, which are based on offering production-driven financial incentives to farmers, toward novel incentive mechanisms and integrated landscape-level approaches where direct links between people and nature are fostered to build socioeconomic, and ultimately socioecological, sustainability (de Snoo *et al.* 2013; Bennett *et al.* 2016; Fischer *et al.* 2017). Moving toward HNV farmlands that function as "seeds of a good Anthropocene" therefore requires strengthening the social component of the HNV farming system so that farmers and communities can achieve socioeconomic viability and improve their quality of life while at the same time preserving the cultural and natural heritage of HNV landscapes.

The core requirements (targeting policy, practice, and research) presented in Panel 2 (see also WebPanel 1) must be implemented if HNVs are to become socioeconomically viable

Panel 2. Fostering the socioeconomic viability and appeal of socioecological systems underlying HNV farmlands

Promoting societal demand, recognition, and rewards for HNV farming systems is essential for stimulating the required paradigm shift toward increasing the socioecological viability and public appeal of HNV farmlands in the future. Achieving such goals requires, for example, designing HNV farmlands labels or brands at the local or regional scales to develop and foster an HNV-specific market (value chains).

Empowering HNV farmers and rural communities through social innovation requires the promotion of capacity building, networking, and cooperation among farmers, as well as between farmers and researchers, local or regional governments, and policy makers, to facilitate knowledge transfer.

Broadening and improving services and well-being in HNV communities to slow rural population decline: refers to basic services such as education, health, culture, and infrastructure, such as access to the internet, roads, water supply, etc.

Fostering technological innovation in HNV farming systems requires the development and testing of new approaches linking technological and social innovation in HNV farming (eg designing new uses for HNV goods, such as cork in the Mediterranean region).

Encouraging multifunctionality and economic diversification in HNV farming systems is essential for building long-term socioeconomic and socioecological sustainability in the future, such as through the development of farm shops, niche products, and on-farm processing facilities, or by creating new business opportunities (eg ecotourism, educational facilities and services, etc).

Rewarding HNV farmers for the delivery of ecosystem services is vital to ensure that HNV farmlands are socioeconomically viable in the future. This should involve either direct financial support, or to move toward the definition and implementation of positive discriminatory measures to reward HNV farmers.

systems (EIP-AGRI 2016). These requirements include increasing societal recognition of the ecosystem services delivered by HNV systems, adopting new paradigms in public interventions (eg within agricultural policies), empowering farmers and rural communities, fostering technological innovation, and promoting multifunctional landscapes. The order of the requirements listed in Panel 2 does not reflect their relative importance, as the definitions and implementation of relevant strategies must be adapted and combined to fit the unique contexts of different regions.

Overall, we argue that reducing reliance on funding derived from farm production and focusing on payments for ecosystem services (PES) arrangements would help motivate farmers to continue supplying the wide range of non-marketable public goods and services provided by "viable HNV farmlands". PES schemes (Panel 2) – particularly results-based instruments that build on farm management decisions known to foster biodiversity or ecosystem services – are seen as effective ways of increasing efficient use of public funds for sustainability goals (Birge *et al.* 2017). An approach based on rewarding farmers for the wide range of values delivered to society could be a pathway to ensuring the viability of HNV farmlands while at the same time stimulating innovation in managing farmlands for ecosystem service delivery and increasing the efficient use of public funding.

Conclusions

HNV farmlands build on an exceptional body of traditional ecological knowledge and constitute socioecological systems that, under specific conditions (eg acceptability, cost–benefit, socioecological viability, ease of implementation), can contribute to sustainability and improve human well-being (Bennett *et al.* 2016). To date, awareness of the importance of HNV farmlands has primarily stemmed from knowledge of their role in biodiversity conservation. Such a perspective on its own has not been enough to slow the decline of HNV farmlands. Here, we argue that HNV farmlands and their underlying farming systems are inherently adapted to the natural conditions where they have been implemented and are highly multifunctional, contributing to agricultural production while enhancing biodiversity conservation and providing a wide range of ecosystem services. As such, increasing the socioeconomic viability and appeal of HNV farmlands should be a high priority if the UN Sustainable Development Goals are to be met. To advance HNV farmland management, change needs to be seen as an opportunity rather than as a constraint. Anticipating the synergies and trade-offs between our hypothesized alternative future scenarios will require context-specific, data-driven research that covers a broad suite of social, economic, biodiversity, and ecosystem services indicators at the landscape scale. Only then will it be possible to identify the most effective ways of ensuring the future socioecological viability of HNV farmlands.

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