



Agroforestry for sustainable landscape management

Tobias Plieninger^{1,2} · José Muñoz-Rojas³ · Louise E. Buck^{4,5} · Sara J. Scherr⁵

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Abstract

Agroforestry and sustainable landscape management are key strategies for implementing the UN-Sustainable Development Goals across the world's production landscapes. However, both strategies have so far been studied in isolation from each other. This editorial introduces a special feature dedicated to scrutinizing the role of agroforestry in sustainable landscape management strategies. The special feature comprises eleven studies that adopt inter- and transdisciplinary perspectives, integrating ecological, agricultural, and socio-economic sciences, and in some cases also practical knowledge. The studies relate to a range of different ecosystem goods and services, and to a diversity of societal sectors (e.g., agriculture, forestry, nature conservation, urban planning, landscape protection) and demands, including their mutual synergies and trade-offs. They inform land-use policy and practice by conceptualizing agroforestry as a set of “nature-based solutions” useful to help tackle multiple societal challenges. The studies encompass four themes: social-ecological drivers, processes, and impacts of changes of agroforestry landscapes; the sustainability outcomes of agroforestry at landscape scale; scaling up agroforestry through multi-stakeholder landscape strategies; and development of conceptual and operational tools for stakeholder analysis in agroforestry landscape transitions. Key steps to harness agroforestry for sustainable landscape management comprise: (i) moving towards an “agroforestry sustainability science”; (ii) understanding local land-use trajectories, histories, and traditions; (iii) upscaling agroforestry for landscape-scale benefits; (iv) promoting the multiple economic, environmental, social, and cultural values of agroforestry; (v) fostering inclusive forms of landscape governance; and (vi) supporting the innovation process of agroforestry system analysis and design.

Keywords Integrated landscape management · Landscape approach · Multi-stakeholder strategies · Sustainable development goals · Transformative change · Ecosystem services

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✉ Tobias Plieninger
plieninger@uni-goettingen.de

¹ Faculty of Organic Agricultural Sciences, University of Kassel, Kassel, Germany

² Department of Agricultural Economics and Rural Development, Georg-August-Universität Göttingen, Platz der Göttinger Sieben 5, 37073 Göttingen, Germany

³ MED-Mediterranean Institute for Agriculture, Food and the Environment, Universidade de Évora, Colégio dos Regentes Agrícolas, Herdade de Mitra, Valverde-Évora 7006-554, Portugal

⁴ Department of Natural Resources, Cornell University, Ithaca, NY 14853, USA

⁵ EcoAgriculture Partners, 3057 Nutley Street, Suite 193, Fairfax, VA 22031, USA

Introduction

Across much of the world, agricultural systems, ecosystem health, landscape integrity, and rural resource-based livelihoods are in crisis, with major planetary boundaries having already been transgressed (Campbell et al. 2017; Díaz et al. 2019; Gordon et al. 2017). Over the next few decades, agriculture and food systems likely will be forced to go through an extraordinary transition to meet food production needs more sustainably. This is especially relevant in a global context under which climate change, growing populations, and regional inequalities and economic transformations all pose complex and largely intractable challenges for rural landscapes (Gordon et al. 2017; Willett et al. 2019). Navigating these challenges more sustainably implies identifying new ways to manage our natural resource base to secure the full range of ecosystem goods and services potentially provided

by landscapes, capitalizing on synergies and reducing trade-offs (Howe et al. 2014). Biodiversity and ecosystem conservation strategies are also in urgent need of transformation, embedding them more deliberately into increasingly production-oriented landscapes and considering human well-being in a more inclusive sense than in the past (Mace 2014; Palomo et al. 2014).

The 17 UN-Sustainable Development Goals (SDGs) and their associated targets and indicators offer strategic guidance for such transformation of global land and resource use toward sustainability (Kanter et al. 2016). The SDGs emphasize the harmonization of environmental, economic, cultural, and societal policy agendas, building on three basic principles: indivisibility—all goals need to be implemented; inclusion—all people shall benefit; and acceleration—the need for actions that render multiple development dividends (Mann et al. 2018). Public policy actions across administrative scales from the international to the municipal for promoting the SDGs depend on financial commitments, political and societal will, and appropriate legal frameworks. However, ecological knowledge and stewardship fostered by local communities, businesses, land-owners, managers and users, and civil society are at the core of implementing the SDGs in production landscapes (Bieling and Plieninger 2017). Thus, only close communication between land-use actors, broader civil society, the scientific community, and the public and policy sectors can lead to desired SDGs outcomes in terms of better planning, use and management of biodiversity and ecosystem services, alleviation of poverty, security of livelihoods, and more efficient and better coordinated governance systems (Bridgewater et al. 2015).

Sustainable landscape management is a key strategy to achieve the SDGs in agricultural and forestry production landscapes globally (Bürgi et al. 2017; Thaxton et al. 2015). Sustainable landscape management is also termed “integrated landscape management (an umbrella term encompassing a wide range of diverse communities of practice; Scherr et al. 2013) or “landscape approach” (reflecting the 10 principles defined by Sayer et al. (2013)). Specifically, sustainable landscape management conceives conservation and restoration of biodiversity, the production of food, the protection of critical ecosystem services, and rural livelihoods as joint objectives, rather than dealing with them in isolation or in direct confrontation (Tanentzap et al. 2015). Landscape approaches to achieve sustainability are all multi-stakeholder and multi-objective, and they explicitly address spatial interactions (Angelstam et al. 2019).

Sustainable landscape management is being implemented via landscape-level governance platforms and partnerships throughout the world (Angelstam et al. 2019), providing the mechanisms by which the SDGs can become enacted (Reed et al. 2016). Hundreds of bottom-up initiatives of sustainable landscape management have been screened continent by

continent in a series of publications (Carmenta et al. 2020; García-Martín et al. 2016; Milder et al. 2014; Zanzanini et al. 2017).

SDG implementation through sustainable landscape management builds on multifunctional land-use systems that contribute to the mutual alignment of frequently confronted production and conservation aims (O’Farrell and Anderson 2010). Agroforestry systems are defined as landscape units comprising land uses that combine aspects of agriculture and forestry, including the agricultural use of trees (Van Noordwijk 2019). They represent a paradigmatic example of agroecological land-use systems. They hold promise to play a major role in the transformation of agriculture towards achieving the SDGs (Waldron et al. 2017), especially regarding the mitigation and adaptation to climate change (Mosquera-Losada et al. 2018). Forty-three percent of the world’s agricultural lands have a tree cover of at least 10% (Zomer et al. 2016). Although not all of these land-use types and landscapes include explicit agroforestry systems, this estimate indicates that the potential of using agroforestry for sustainable landscape management is vast.

Scientific studies of agroforestry systems are numerous and long-established and have connected land-use science, policy, and practice, demonstrating the societal benefits of this multifunctional land-use (Van Noordwijk 2019). The scientific literature on sustainable landscape management is strongly on the rise as well (Arts et al. 2017). However, most of the agroforestry literature is typically place-specific and often focusing on the agricultural sciences. In contrast, the literature on sustainable landscape management is broader in both scope and geographic focus. With this special feature, we fill the niche of linking the agroforestry and sustainable landscape management communities. By doing this, we emphasize agroforestry as a key asset to sustainable landscape management worldwide, while making the concept of sustainable landscape management more tangible for agroforestry-related land-use practice and policy.

This special feature is dedicated to scrutinizing the role of agroforestry in sustainable landscape management strategies and also, vice versa, how the latter might help improve the application, scaling, and sustainability of agroforestry systems. In particular, studies included in this feature examine:

- Social-ecological drivers, processes, and impacts of the expansion, decline, and qualitative changes of agroforestry landscapes, including urbanization processes and effects of state interventions,
- The performance of agroforestry in contributing to multiple sustainability objectives at landscape scale,
- Upscaling of agroforestry through multi-stakeholder landscape strategies, and
- Conceptual and operational tools for analyzing agroforestry adoption and impacts at landscape scale.

Sustainable landscape management

The concept of sustainable landscape management implies managing agriculture and natural resources simultaneously for food and fiber production, support of biodiversity and ecosystem services, and fostering overall contributions to human well-being. A landscape approach enables synergies and trade-offs among ecological, economic, cultural, and social objectives to be examined at a larger-than-farm scale to reveal how interactions among different land uses are complementary and/or competing. Management strategies within and across the four aforementioned objectives, thus, can be negotiated to produce an optimal balance within any given landscape context. Adopting such an approach to management implies working across sectors to ensure that knowledge and information as well as land uses, markets, and policy strategies are adequately integrated. This “integrated” approach to realizing sustainable landscapes is, thus, a fundamental precept of sustainable landscape management (Denier et al. 2015; Scherr et al. 2013).

The idea of integrated management for sustainable landscapes (“integrated landscape management”, ILM) arose to unite a proliferation of terms used to express various applications of conservation and sustainable development. It emerged along the decade following the 1992 UN Conference on Environment and Development and was inspired by the Brundtland Commission report, which had coined the term “sustainable development” (Brundtland 1987). During this period, the biodiversity and forest conservation communities recognized landscape approaches in strategies to address limitations of integrated conservation and development projects that sought to improve local livelihoods in the context of protected area management (Sayer and Campbell 2004). At the same time, the notion of “forests in landscapes” arose to help advance ecosystem approaches to sustainability (Sayer and Maginnis 2007).

The Pilot Assessment of Global Ecosystems: Agroecosystems in 2000 [a precursor to the Millennium Ecosystem Assessment (2005)] used spatial analyses to graphically illuminate overlapping uses of land for agricultural production, biodiversity conservation, and multiple other ecosystem services at a global scale (Wood et al. 2000). This inspired collaborative research by the CGIAR’s Future Harvest program and IUCN to document and propose strategies for managing agriculture at landscape scale to better harmonize the rapid changes in land use with biodiversity conservation goals, initially using the term “ecoagriculture” before shifting to ILM (McNeely and Scherr 2003; Scherr and McNeely 2008). The authors used various applications of agroforestry to help illustrate the concept. Operationalizing these constructs rested on

the concept and practical strategy of adaptive collaborative management (Buck et al. 2001), which embraced the employment of science together with participatory decision-making through a range of collaborative processes in an adaptive management framework.

Sayer et al.’s (2013) landmark publication on principles of a landscape approach appeared at the same time that Scherr et al. (2013) distilled vital elements of integrated landscape management and documented more than 80 communities of practice aligned with such approach. The two intersecting constructs helped pave the way for a burgeoning community of practice, as exemplified by the Global Landscapes Forum knowledge platform on integrated land use that fosters a holistic approach to creating sustainable landscapes (www.globallandscapesforum.org). Simultaneously, research publications quickly expanded in this arena. For example, Harvey et al. (2014) and Minang et al. (2014) explored climate smart landscapes; Reed et al. (2016), Sayer et al. (2017), and Opdam (2018) tackled core questions that arise in implementing the approach; Buck et al. (2017) and Kusters et al. (2018) addressed landscape partnerships; Caron et al. (2017) integrated sustainable landscapes with territorial development. These and others signal a vital and maturing field of practice and inquiry, while lastly, Angelstam et al. (2019) explored how to bring together landscape concepts and approaches within the ecosystems services umbrella to devise sustainable landscape governance.

Agroforestry

The basic idea behind agroforestry is that the combination of trees and crops in spatial or temporal arrangements results in greater structural and functional complexity compared to monoculture production (Jose 2009). This complexity leads to gains in efficiency of capturing and utilizing nutrients, light and water, improves food and nutritional security, results in valuable cultural landscapes, and mitigates environmental degradation—thus offering a sustainable alternative to input-intensive “single commodity” production (Nair et al. 2017). While in the Global South poverty alleviation, increasing food security, and halting deforestation have been among the major reasons for promoting agroforestry, in the Global North issues of fostering rural quality of life and cultural values, improving water quality, controlling soil erosion, and conserving biological diversity have been important drivers (Nair 2007). A number of global and regional-level reviews provided evidence that agroforestry offers a wide range of environmental, social, cultural, and economic benefits at landscape scale (e.g., Rosenstock et al. 2019; Torralba et al. 2016). Under such a logic, agroforestry is a key strategy for the “perennialization” of agriculture aimed at establishing permanent vegetative cover for ecosystem

protection. This may include the incorporation of relatively small amounts of perennial vegetation in strategic locations within agricultural landscapes dominated by annual crops (Asbjornsen et al. 2014), or conversion of much larger areas of land, still in strategically located parts of the landscape.

Historically, multiple forms of agroforestry have developed over the centuries across many regions, cultures, and ecosystems of the world. For example, planned agroforestry has been dated back to 2500 BC in Europe (Eichhorn et al. 2006). Well-known examples of agroforestry systems across the world include the Chattisgarh system of multipurpose trees integrated into rice cultivation in India (Viswanath et al. 2000), the Parkland system of West Africa (Fifanou et al. 2011), and the traditional orchard meadows called *Streuobst* in Germany (Plieninger et al. 2015b). Many of these traditional and location-specific agroforestry systems have gone into oblivion with agricultural modernization, although some—termed “Cinderella systems” (Nair et al. 2017)—have recently been rediscovered as potential models for sustainable land-use and territorial development. While some have fairly high production, this does not tend to be the norm. At times, this is due to the emphasis in modern analysis on the output of specific commercially relevant commodities from the system rather than the combined output of multiple products and services. Moreover, little research and technology development activity has been devoted to these systems. Traditional agroforestry systems, most notably silvopastoral systems (Plieninger et al. 2015a), are still found extensively in many parts of the world, but are often in decline due either to agricultural intensification or land abandonment (Godinho et al. 2016; Nerlich et al. 2013).

Novel, improved, and more standardized agroforestry systems have been promoted since the 1980s, first through development cooperation in the tropics and subtropics, catalyzed by the World Agroforestry Centre (ICRAF), and more recently also as an alternative land-use approach in Europe and North America (Nair 2007). Compared to traditional agroforestry, improved agroforestry systems are often less diverse and tend to provide a narrower range of ecosystem services, though this depends on specific systems, places, and management options. On the other hand, they are highly productive—often even more productive than segregated forms of agricultural and forestry production (Nair 2007). For example, land-use efficiency of improved agroforestry systems (in terms of agricultural and forestry crop yields) in Europe has been estimated to be up to 40% higher than that of conventional farming systems (Graves et al. 2010). Often incorporating elements of indigenous and local knowledge, these improved systems have been intensively investigated by modern science. They extend out across vast landscapes in the Global South, thanks to local land-use traditions and incorporation of tree products on farms for income diversification. They tend to expand more incrementally in the

Global North, typically due to a combination of economic, political, technical, and socio-cultural barriers (García de Jalón et al. 2018).

Agroforestry as a land-use and landscape concept is in constant evolution (Van Noordwijk 2019). First, agroforestry was used as a collective name for specific practices that involved farmers and trees at the plot level, often with a focus on tree soil crop interactions. In the 1990s the idea of using agroforestry for increased landscape multifunctionality emerged, putting landscapes and livelihoods (i.e., the landscape level) into the foreground. Most recently, attention to agroforestry has been moving to the policy level, with many efforts dedicated to removing the disaggregation between agricultural, forestry, and other sectorial policies, including especially environmental ones, and advocating for coherent policies across all land uses. Often, these efforts are framed as contributions to achieving the Sustainable Development Goals (Van Noordwijk 2019).

Characteristics of this special feature

This special feature assembles eleven studies dedicated to exploring the mutual interactions between agroforestry and sustainable landscape management, focusing on the potential synergies and related advantages to be gained (see overview in Table 1). It finds its origin in two sessions on agroforestry landscapes that took place at the Fourth World Congress on Agroforestry, held from 20 to 22 May 2019 in Montpellier, France (<https://agroforestry2019.cirad.fr>). This congress was an authoritative global agroforestry event that brought together a large number of committed agroforestry researchers, policy makers, farmers, donors, government officials, students, the private sector, and civil society members from the Global South and North. The mission of this congress was to strengthen the links between science, society, and policy around agroforestry.

In this special feature, 63 authors take up this challenge, presenting eleven original studies on agroforestry and landscape approaches. Studies were carried out in Canada (Laroche et al. 2020), Ecuador (Buck et al. 2020), France (Guillermé et al. 2020; Therville et al. 2020), Nicaragua (Andreotti et al. 2020), Romania (Hartel et al. 2020), and Thailand (Dumrongrojwatthana et al. 2020) (Fig. 1). Interestingly, a number of articles describe comparative research that has been performed across two regional landscape corridors (Buck et al. 2020); between two protected areas (Therville et al. 2020); between the four tropical countries of Honduras, Indonesia, Peru, and Uganda (Zinngrebe et al. 2020); across the Mediterranean Basin (Flinzberger et al. 2020; Wolpert et al. 2020); and across ten agroforestry landscapes and land-use systems in the European Union (Rolo et al. 2020). Studies were carried out at local ($n=3$), regional ($n=6$), national

Table 1 List of contributions focusing on diverse topics, world regions, and agroforestry systems

Study #	Topic	Agroforestry system	Region/countries	Reference
1	Historic drivers and trends of change of agroforestry landscapes	Chestnut-, cork, and olive-based agroforestry systems	Nine regions of the Mediterranean Basin	Wolpert et al. (2020)
2	Functional relationships between traditional agroforestry landscapes and invasive species	Mountain silvopastoralism	French Pyrenees (South France)	Guillerme et al. (2020)
3	Stakeholder views on resilience improvements of European agroforestry systems	Wide range of agroforestry systems of high natural and cultural value	Eleven European countries	Rolo et al. (2020)
4	Driving forces and impacts of land-use change in marginal tropical agroforestry systems	Rice/sugar palm agroforestry systems	Thailand	Dumrongrojwattana et al. (2020)
5	Visual assessments for social coherence of agroforestry systems	Intercropping systems	Québec (Canada)	Laroche et al. (2020)
6	Social-ecological linkages in traditional agroforestry systems	Wood-pastures	Central Romania	Hartel et al. (2020)
7	Labeling as a tool for sustainability in agroforestry landscapes	Multiple agroforestry systems and elements	Mediterranean Basin	Flinzberger et al. (2020)
8	Participatory games and backcasting for transitioning towards sustainable agroforestry landscape management	Smallholder coffee agroforestry systems	Nicaragua	Andreotti et al. (2020)
9	Integrated landscape management for upscaling agroforestry	Multifunctional landscapes	Ecuador	Buck et al. (2020)
10	Operationalising a landscape approach through agroforestry linking conservation and farming actors	Trees on tropical farms across diverse contexts and farming systems	Honduras, Peru, Indonesia, Uganda	Zinngrebe et al. (2020)
11	Policy frameworks and regimes in protected areas rich in agroforestry	Mediterranean plain and mountain agroforestry systems, isolated trees in fields, hedgerows, grazed orchards, silvopastures	South France	Therville et al. (2020)

($n = 1$), and supranational scales ($n = 1$). Often, agroforestry landscapes do not show sharp spatial boundaries, but form fuzzy land-use and landscape units. Study areas were variously delimited by administrative ($n = 3$), biophysical ($n = 5$), and cultural-historic ($n = 3$) borders.

The types of agroforestry systems under investigations are diverse. Some studies focus on very specific and localized agroforestry systems, e.g. on combined rice and sugar palm systems in Southeast Asia (Dumrongrojwattana et al. 2020); on coffee-based systems in Central America (Andreotti et al. 2020); or on olive-, chestnut-, and cork oak-based tree cropping systems in the Mediterranean Basin (Wolpert et al. 2020). Others include a broader range of traditional and novel, silvopastoral and silvoarable systems (e.g., Buck et al. 2020; Therville et al. 2020). The contributions typically triangulate various qualitative and quantitative methods and partly combine approaches from the social, ecological, agronomical, and geographical sciences. Many rely on participatory methods, such as serious games

(Andreotti et al. 2020), Delphi assessments (Flinzberger et al. 2020), or stakeholder deliberations (Rolo et al. 2020).

Although highly diverse in questions, concepts, methodological approaches, scales, and insights, all papers in the special feature share a focus on agroforestry, being showcased as a microcosm for studying wider issues about the sustainability of human–nature interactions through the prism of rural landscapes and land-use synergies and trade-offs. In particular, they share the following common features:

- All studies assume an interdisciplinary perspective, integrating ecological, agricultural, geographical, and socio-economic sciences perspectives,
- Most of them are transdisciplinary in nature, considering multiple forms of scientific and practical knowledge on agroforestry,
- They relate to a range of different ecosystem goods and services, and to a diverse set of societal sectors (e.g., agriculture, forestry, nature conservation, urban plan-

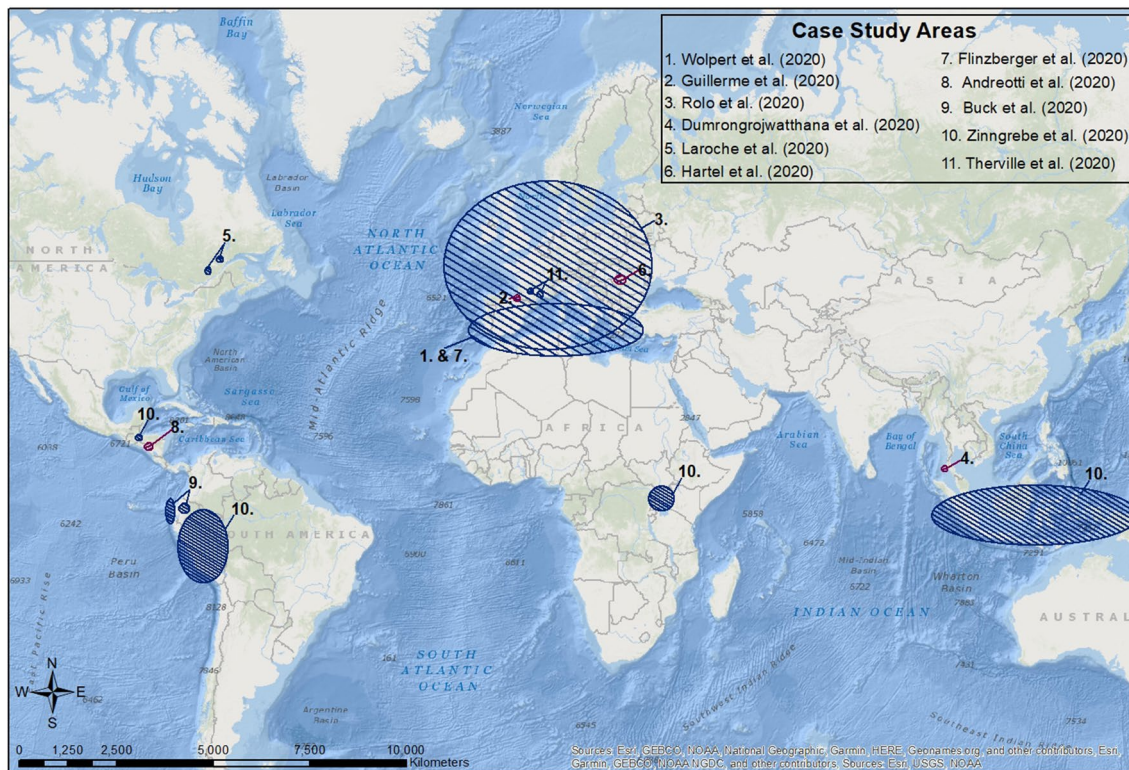


Fig. 1 Geographic distribution of the studies included in this special feature. Blue areas indicate studies that compared multiple study areas. Purple areas indicate single-area studies

ning, landscape protection) and actively consider synergies and trade-offs between different societal demands, thus covering different aspects of sustainable landscape management (Table 2),

- The studies inform land-use policy and practice by conceptualizing agroforestry as a set of “nature-based solutions” to help tackle multiple societal challenges, thus linking to the UN-Sustainable Development Goals.

Social-ecological drivers, processes, and impacts of expansion, decline, and qualitative changes of agroforestry landscapes

Agroforestry landscapes are overall characterized by complex dynamics, involving mutually interacting governance institutions, actors, and networks that act across spatial–temporal scales (Pastur et al. 2012). Acknowledging the complexity of agroforestry landscapes requires that they be examined through a social-ecological lens (Plieninger and Huntsinger 2018). This includes identifying interactions among multiple ecosystems functions and services, and related drivers, processes, and impacts (Lescourret et al. 2015). This is especially pertinent at a

time of rapid land-use change in production landscapes due to population, market, socio-cultural, climate, and ecological changes.

In response to these challenges, Wolpert et al. (2020) explore land-use changes across different Mediterranean tree crops and contrasting landscapes over the past 200 years. The authors identified a general trend in the last 70 years from multifunctional tree-crop landscapes towards intensification or abandonment, with the southern fringe of the Mediterranean trending towards intensification, and the northern landscapes towards abandonment. Socio-cultural drivers are confirmed as key elements for change, as is the high potential of tree-crops to contribute to future resilience of landscapes.

Equally in the Mediterranean context, but at a local scale, Guillaume et al. (2020) study the relationship between agroforestry and invasive species, an important and understudied issue for sustainability. The authors investigate the evolution of a traditional agroforestry Pyrenean landscape where invasive species are abundant, using high-resolution spatial technologies. The results, which show that invasive species have spread in parallel to the abandonment of farmlands, are relevant for land-use planning. They raise questions about the sustainability and effects of current management practices on landscape-scale biodiversity.

Table 2 Principles of the landscape approach (Sayer et al. 2013) addressed by each of the studies in the special feature

Study #	Continual learning/ adaptive management	Common concern entry point	Multiple scales	Multi- function- ality	Multiple stakehold- ers	Negotiated/trans- parent change logic	Clarification of rights/responsibili- ties	Participatory/user- friendly monitoring	Resilience	Strengthened stakeholder capacity
1	x		x	x	x			x	x	
2	x	x				x	x		x	
3		x	x	x	x				x	x
4				x	x	x		x	x	
5	x			x	x			x	x	x
6	x			x	x		x	x	x	x
7			x	x		x	x		x	x
8	x	x	x	x	x	x	x	x	x	x
9	x	x	x	x	x	x	x		x	x
10		x	x	x	x	x		x		x
11			x	x	x	x	x	x		

Rolo et al. (2020) look at how traditional agroforestry systems are declining across Europe, largely driven by their poor economic performance. This loss of agroforestry is ongoing although such land-use systems deliver a wide range of ecosystem services, and thus can be considered as high-value-farming systems. To tackle this paradox, participatory research was conducted with ten European stakeholder groups to discuss pathways to improve the sustainability of “High Nature and Cultural Value agroforestry”. The authors conclude that existing solutions match poorly with the key challenges identified. Further, to become more effective, solutions require in-depth understanding of the diversity of contexts of agroforestry systems, along with novel approaches to bottom-up and collective actions.

Rainfed lowland rice and sugar palm hedges in SE Asia, which play a crucial role in the resilience of tropical agroecosystems, are studied in Dumrongrojwattana et al. (2020). Powerful drivers are transforming these iconic cultural landscape elements. Combining remote sensing and interviews, the authors quantify and qualify land-use changes behind the diversification of farming and off-farm activities. They highlight recent sugar palm expansion and extreme climatic events, resulting in threats to these emblematic, and yet increasingly vulnerable cultural agroecosystems.

Sustainability outcomes of agroforestry at landscape scale

Landscape approaches aim to reconcile targets for biodiversity, food production, livelihoods, and human well-being, along with related cultural and social values (Arts et al. 2017). In such pursuit, the landscape is considered an optimal spatial unit for governance and delivery of multi-functionality (Angelstam et al. 2019), with integrated landscape management potentially driving change towards greater levels of sustainability. Thus, agroforestry systems, when considered from a landscape perspective, can become key assets for improving sustainability.

Laroche et al. (2020) examine how agroforestry intercropping systems can provide multiple ecosystem services in regions where agricultural systems are becoming more intensive. Social perceptions are evaluated using online questionnaires with photomontages for two regions of Quebec (Canada) to examine contributions to landscape sustainability. This study reveals that most agroforestry intercropping systems are as socially appreciated as ordinary agricultural landscapes. In view of this, the authors highlight that any design recommendations must be context-specific to fully respond to the social expectations that these landscapes frequently pose.

Focusing on scattered trees in Central Romania, Hartel et al. (2020) analyze their key roles in shaping local

communities, both economically and socio-culturally. They argue that the values that people attach to these elements of agroforestry are key for landscape sustainability. Using network analysis, the study brings light to the value network around the scattered mature and large old trees in traditional wood pastures and how the “removal” of values affects the wood-pastures, when they are considered as social-ecological systems. In this way, this study proves how adopting a value-network approach is useful for improving understanding of the values that local people attribute to agroforestry landscapes, and thus also ultimately for improving sustainability.

Flinzberger et al. (2020) look at the expanding empirical evidence that agroforestry systems have the potential to support a diversity of social and ecological values in agricultural landscapes across the Mediterranean Basin. They examine the use of market labels that both communicate to the consumer that the product is sourced through sustainable management along the supply chain and at the same time secure the financial sustainability of farms. A Delphi survey finds that 12 out of 17 Sustainable Development Goals are relevant for agroforestry systems, and that related marketing instruments including eco-labels, social labels, and Geographic Indications are especially well-positioned to help achieve these goals through agroforestry. An agroforestry label defined in the form of a Geographic Indication fits especially well for this purpose.

Scaling up agroforestry through multi-stakeholder landscape strategies

Sustainable landscape management requires long-term institutional arrangements among multiple stakeholders to negotiate, advocate for, and jointly implement responses to evolving challenges and opportunities for natural resource management (Sayer et al. 2013). Such coalitions at landscape and supra-farm governance levels can potentially play a significant role in scaling up agroforestry.

Andreotti et al. (2020) explore the re-design of a complex coffee-based agroforestry system in central Nicaragua to transition towards greater sustainability. The findings show how a facilitated multi-stakeholder process can enable co-creation of transition pathways, providing a learning platform for sharing knowledge and practices and discussing opportunities and constraints. Such discussions are essential to build a shared stakeholder understanding of the current situation and future options, and a foundation for developing a shared vision and taking collective action for integrated landscape management.

Buck et al. (2020) document the institutional innovations associated with integrated landscape management in

the Amazon and Chocó-Andean BioCorridor of Ecuador. These platforms led to scaling agroforestry systems after initially stagnant field-focused promotion efforts. The authors demonstrate how five key elements of ILM—shared goals, cross-sectoral collaboration, community engagement, integrated spatial planning of agroforestry and related land-use systems, and market and policy support—work synergistically to advance the knowledge-intensive and adaptive collaborative management processes needed to scale up agroforestry adoption and to develop a coherent scaling strategy.

Zinngrebe et al. (2020) argue that understanding of the roles of different actors in trees-on-farm governance should inform strategies of multi-stakeholder landscape platforms and of national programs. Through social network analysis in Honduras, Peru, Indonesia, and Uganda, the authors find that implementation of agroforestry-specific policy instruments requires complementary structures for regulation, finance, and information. Different functions of actor groups require coordination through facilitated learning processes. “Bridging” actors, such as farmer associations and local governments, can play an important role in facilitating such processes. The authors recommend integrating support for agroforestry across all relevant governance processes to produce effective outcomes.

Therville et al. (2020) investigate the “policyscape” of agroforestry, meaning the articulation between multiple policies that impact a diversity of agroforestry systems, in the Ventoux Biosphere Reserve and Verdon Regional Nature Park, in France. The results of in-depth interviews with practitioners and institutional representatives reveal 121 policy instruments. Only a minority of these were specific to agroforestry, while numerous sectoral instruments indirectly impacted agroforestry systems at a landscape scale. They conclude that it is essential to consider interactions—of places, people and networks—not only between different forms of agroforestry, but also with other agroecological practices and territorial issues.

Tools for stakeholder analysis in agroforestry landscape transitions

Analyzing and fostering agroforestry for sustainable landscapes requires gaining better understanding of stakeholder perceptions, and advancing multi-stakeholder processes. Four articles in this set evaluated innovative tools and methods for such analyses: Net-Map, Delphi survey, a visual appreciation tool, and combined participatory fore- and backcasting. All of the studies generated both useful research findings, and important inputs for advancing integrated landscape management in real-world practice.

Zinngrebe et al. (2020) demonstrate how the Net-Map tool proved powerful in building and understanding critical

aspects of collaboration among actors in selected socio-ecologically diverse landscapes. The study generates novel insights into structural characteristics of effective governance, including the benefits of building on established networks of local land users, and shed light on how flows of finance, regulation and information affect potential for agroforestry support.

Flinzberger et al. (2020) apply an expert Delphi survey to evaluate terms to convey sustainability in agroforestry systems through of labeling agroforestry products. Delphi surveys have been frequently performed in socio-economic studies. However, this study demonstrates that this method may prove as a powerful tool for application also in the environmental sciences, by virtue of its potential to elicit and synthesize expert knowledge systematically.

Laroche et al. (2020) design a tool for evaluating the influence of agroforestry system design features on visual appreciation by rural residents. The tool includes an online survey and a suite of photomontages that depicted conventional agricultural landscapes and agroforestry intercropping systems. It is calibrated to examine the social perceptions of agroforestry intercropping systems within specific landscape contexts to optimize their designs and contribution to landscape sustainability. The authors find the coupling of visual assessments and qualitative comments useful in understanding the “social coherence” of intercropping across different landscape contexts.

Andreotti et al. (2020) combine participatory forecasting and backcasting to explore agroforestry management strategies for envisioning more sustainable landscapes. The methods allow examination of farmer decision-making processes and farming strategies, as well as future visions for sustainable landscape management by groups of technicians, researchers and municipal officials. The approach shows potential to facilitate discussions on landscape planning among the various types of stakeholders engaged, leading to a stepwise pathway for reaching the collectively envisioned future landscapes.

Conclusion

In this editorial, we explore the relations between agroforestry and sustainable landscape management, and the potential of agroforestry landscapes to contribute to achieving multiple Sustainable Development Goals of the UN. The agroforestry systems investigated here serve as microcosms that allow for the study of broader sustainability issues and challenges, in particular regarding questions of managing complexity and multiple scales. The contributions to this special feature reflect on various options of how sustainable landscape management can inform and advance the scaling up of agroforestry. Likewise, agroforestry as a land-use

production system can become a key component of strategies for implementing sustainable landscape management.

Based on the studies in the special feature, we distill the following messages for a coming together of agroforestry and sustainable landscape perspectives (Fig. 2).

- Agroforestry has been considered a niche discipline for too long. Rather, agroforestry should become a distinctive research area under the umbrella of sustainability science, thus moving toward an “agroforestry sustainability science”. Integrating agroforestry’s central role in sustainable landscape management may help overcome the lack of adoption and maintenance that is a challenge to many agroforestry practices and systems.
- Natural resource management is determined by path dependencies that often have developed over decades, if not centuries and millennia. Agroforestry for sustainable landscape management, therefore, needs understanding of local land-use trajectories, histories, and traditions. This includes gaining a better understanding of farmers’ attitudes toward agroforestry over time, as farmers are the key actors driving historic and current land-use change.
- Agroforestry strategies should not be confined to the farm and plot scales. Meaningful contributions to the Sustainable Development Goals depend on upscaling agroforestry to generate benefits at landscape scale. A diversity of agroforestry practices, implemented in the right locations of a landscape, counting with the right management, can not only benefit the farmers and land managers practicing them, but also other actors and their networks in the landscape.
- To sustain the long-term practice of agroforestry, considering and promoting its multiple economic, environmental, social, and cultural values as well as the synergies among them is essential. This means actively supporting market and business development that render agroforestry viable, so that these land-use systems and related landscapes can retain key values as they evolve dynamically over time.
- Implementation of the Sustainable Development Goals requires fostering and experimenting with inclusive forms of landscape governance, mainstreaming policy fields also beyond public agricultural and forestry policies. This includes fostering strong multi-stakeholder coalitions within landscape units, and more efficient coordination, cooperation, and shared and mutual learning of policy and other actors in support of agroforestry upscaling.
- A variety of unique and creative tools should be embraced for supporting the innovation process of agroforestry system analysis and design in the context of sustainable landscape pursuits. These should take into account the multi-dimensional properties of agroforestry in sustain-



Fig. 2 Key messages to harness agroforestry for sustainable landscape management

able landscapes, including their multi-functional land-use characteristics and/or the collaboration requirements in integrated management and governance.

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