Advances in Agroforestry 14

Florencia Montagnini *Editor*

Integrating Landscapes: Agroforestry for Biodiversity Conservation and Food Sovereignty

Second Edition

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Advances in Agroforestry publishes critical reviews and state-of-the-art research results in all areas related to the science and practice of agroforestry worldwide. Its scope covers any aspects of agroforestry research, development, and application from basic knowledge to the latest findings and innovations. This book series brings together exciting contributions in agroforestry as an increasingly prominent land-use that can harmonize productivity and ecosystem conservation at the farmer and landscape levels. Subjects include, but are not restricted to, aspects of agroforestry establishment, management and design, financial and social considerations, as well as functions such as enhancement of environmental services and values.

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This book is dedicated to my father César C. Montagnini who always supported my ideas and showed me the way.

Preface

Agroforestry systems (AFS) are becoming increasingly relevant worldwide as society has come to recognize their multiple roles and services: biodiversity conservation, adaptation and mitigation of climate change, restoration of degraded ecosystems, and tools for rural development. This book summarizes advances in agroforestry research and practice and the effectiveness of AFS to solve the development and environmental challenges the world presents us today.

Currently AFS are considered to be a land use that can achieve a compromise among productive and environmental functions. AFS could play a significant role in rural development even in the most challenging socioeconomic and ecological conditions, but there is still a lot of work to be done to reach these goals. Considerable funding is spent in projects directed at enhancing productivity and sustainability of smallholders' forestry and agroforestry practices. These projects and programs face many questions and challenges, including those related to the integration of traditional knowledge to promote the most suitable systems for each situation, access to markets for AFS products, and scaling up of successful AFS. These complex questions need innovative approaches from varying perspectives and knowledge bases.

This book gathers fresh and novel contributions from authors who provide alternative and sometimes departing insights into these pressing questions. The contributors include researchers, academicians, and practitioners from agroforestry, environmental management, and related fields who approach the issues from varied, unique perspectives. The book focuses on the functions that AFS can provide when well designed and implemented; their role in rural development as they can improve food security and sovereignty and contribute to provision of energy needs for smallholders; and their environmental functions, such as their contribution to biodiversity conservation, increased connectivity of fragmented landscapes, and adaptation and mitigation of climate change. The chapters present conceptual aspects and case studies ranging from traditional to more modern approaches, from tropical as well as from temperate regions of the world, with examples of the AFS functions mentioned above. The chapters discuss current challenges faced by agroforestry researchers and practitioners and propose innovative approaches to tackle them.

In this second edition of the book, the first edition published in 2017 has been revised to incorporate important advances in agroforestry science and practice. With five new chapters and substantial revisions made in most of the others, the scope has been broadened both geographically and thematically. There is more content and contributions from Africa and Asia, adding to the emphasis on the Americas placed in the first edition. New perspectives are added on the achievement of the Sustainable Development Goals (SDGs) and on the contributions of AFS to improved nutrition while preserving indigenous species and resources. The science and practice of agroforestry is evolving rapidly, and the second edition of this book reflects precisely this, thus supporting practitioners and decision makers, who have in their hands the task of promoting and helping agroforestry achieve its biodiversity conservation and food sovereignty goals.

This book comprises three parts: **Part I—AGROFORESTRY CHALLENGES AND ALTERNATIVES**—gives a broad insight into AFS with information encompassing tropical and temperate regions across the globe, beginning with an introduction that summarizes the major challenges for successful agroforestry to date and a chapter on the role of AFS in achieving SDGs. Two new contributions examine the role of forests and trees in providing food security and enhanced nutrition, with one chapter focusing on neglected and underutilized species. Four additional contributions offer regional perspectives and detailed descriptions of AFS across landscapes in different parts of the world.

Part II—FROM SUBSISTENCE TO MARKET-ORIENTED AGRO FORESTRY SYSTEMS—includes ten chapters that embrace the concept of sustainability in the context of AFS at both the farm and landscape levels, with case studies showing the role of agroforestry in biodiversity conservation and food sovereignty across a broad geographic range, with new chapters from West Africa and South Asia. This section also explores the economic value of AFS products for both small-scale (açaí forest farming, guayusa, yerba mate, cacao) and medium to large-scale agroforestry (organic coffee, organic yerba mate), investigating possibilities for accessing global markets as well as examining potential implications on the livelihoods of farmers who have traditionally practiced these systems for their own sustenance.

Part III—ENVIRONMENTAL SERVICES IN MULTIFUNCTIONAL LANDSCAPES—comprises six chapters (in addition to the conclusion) covering how different types and components of AFS contribute to the provision of environmental services. This section places a strong emphasis on the role of AFS in biodiversity conservation, livelihood enhancement, carbon storage, and climate change adaptation and mitigation. A new chapter details the ability of AFS to function as and within biodiversity islands (BI), which are areas of land with greater diversity than the surrounding landscapes, where plant and animal species can thrive without major interference from human activity.

A holistic, multidisciplinary perspective was taken in approaching each theme, encompassing factors and variables from multiple disciplines. This book is directed at professionals and students in a variety of fields related to agriculture, forestry, agroforestry, rural development, restoration, environmental management, ecology, and agroecology.

Northford and New Haven, CT, USA Florencia Montagnini
November 9, 2023

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The main ideas that form the structure and contents of this book were born during meetings and conversations with colleagues whose enthusiasm, energy, and joyful attitude supporting this book made it possible from start to end. The contributors' dynamism, dedication, and persistence drove the rest. Numerous colleagues and friends also helped with their intellectual input and moral support. The contributors acted as independent reviewers of other colleagues' chapters. In addition, other external reviewers generously gave their time to read and offer useful suggestions to improve the chapters.

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About the Editor

Florencia Montagnini has over 30 years of experience researching and teaching in topics on sustainability of managed ecosystems such as forest, tree plantations, and agroforestry systems. Her research encompasses sustainable land-use systems that integrate ecological principles with economic, social, and political factors; the principles and applications of forest landscape restoration; the reforestation of degraded lands with native species; organic farming using indigenous resources; biodiversity conservation in human-dominated landscapes; and biodiversity islands. Since 1989, she has worked as a professor and researcher at the Yale School of the Environment, as well as the Tropical Agriculture Research and Higher Education Center (CATIE). She has written 12 books and almost 300 scientific articles about the ecology of tropical forests, agroforestry systems, native species reforestation, forest landscape restoration, and biodiversity islands.

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Part I
Agroforestry Challenges and Alternatives

Chapter 1
Introduction. Challenges and Achievements in Agroforestry in the New Millennium

Florencia Montagnini

Abstract Agroforestry systems (AFS) are broadly defined as a set of land uses and practices that integrate trees and other woody vegetation into agricultural systems. They are becoming increasingly relevant worldwide as society recognizes their multiple roles and functions: food and energy production, biodiversity conservation, ecosystem restoration, climate change adaptation and mitigation, and tools for rural development. This chapter summarizes advances in agroforestry research and practice and poses questions on the effectiveness of AFS to solve the development and environmental challenges the world presents us with today. Beginning in the 1970s, academic research into AFS emphasized their function as a viable productive alternative to industrial agriculture. Studies focused on AFS design, multipurpose tree/shrub species, and advancing financial evaluations. Later, research turned to alleviating poverty and improving food security. In the last decade, focus has shifted to AFS's role in restoring degraded landscapes, conserving biodiversity, and adapting to and mitigating climate change.

Current challenges to successful AFS include difficulties integrating traditional knowledge with current scientific expertise, the lack of a market for AFS products and services, a need to properly monitor the achievement of set goals, and barriers to scaling up successful AFS. These challenges require innovative solutions from varying perspectives and knowledge bases in order for AFS to successfully bring about multifaceted, beneficial change at multiple scales. The science and practice of agroforestry is evolving rapidly, and the second edition of this book reflects these changes. The appreciation of AFS is increasing among practitioners and decision-makers who can effectively promote their implementation, gaining momentum toward their biodiversity conservation and food sovereignty-harmonizing goals.

Keywords Agroforestry research · AFS challenges · Ecosystem services · Productivity · Rural development

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1 Introduction

When the first edition of this book was written, 193 countries had recently adopted Agenda 2030 for Sustainable Development and its 17 Sustainable Development Goals (SDGs), with targets to be achieved by 2030. The goals and the 169 targets cover a wide range of social, economic, and environmental issues addressing crucial global challenges, including ending hunger and poverty, protecting life below water and on land, advancing sustainable production and consumption, and guaranteeing well-being to all with reduced inequalities (Katila et al. 2020).

Agroforestry systems (AFS) were proposed as a land use that can contribute substantially to achieving many of these goals, especially in reference to SDG2, zero hunger (Montagnini and Metzel 2017; Sunderland et al. 2020; Nair et al. 2021). A consensus is now emerging that multifunctional agriculture that increases food production while simultaneously enhancing social and environmental goals, as committed to in the SDGs, is important not only for smallholders but for the entire farming community. Consequently, the push to move away from the narrow focus on yield toward diversified agriculture that respects and enhances broader goals is gathering momentum. Agroforestry has all the attributes of such a highly multifunctional land use alternative.

In the second edition of this book, several authors address the contribution of AFS to the SDGs, focusing mostly on SDG2 (zero hunger) (Montagnini and Metzel 2024). The acute global impacts of climate change and the onset of Covid-19 have exposed the present cracks in food systems around the world. The need to combat hunger and malnutrition while simultaneously improving the functioning of food systems is now an even greater priority of national and international policymakers around the world, growing in importance since the UN Sustainable Development Goals were announced in 2015 (Katila et al. 2020; Nair et al. 2021). SDG2 aims to address these exact problems. Recently, several publications have been released by researchers working relentlessly toward reducing world hunger, offering insights which form the backbone of change toward reforming global food systems (Katila et al. 2020; Nair et al. 2021). During the last 10 years, there has been a significant evolution in global discourses related to food security, nutrition, and food systems (Gitz et al. 2021; Ickowitz et al. 2021, 2024). Greater emphasis is now placed on malnutrition, on the environmental impacts of food systems, on their capacity to sustainably produce healthy food for all, and on their resilience to climate change and other impacts.

Several authors have recently advanced proposals for innovative rural development paradigms. These focus on empowering local populations who have lived in and cared for rainforests for centuries but are now fighting to survive the effects of deforestation and to preserve rainforests for future generations (Montagnini and Berg 2019; Pimm 2021 among others). For example, Tongele (2022) claims that a "green industrial revolution" must take place for the SDGs to be achieved, by offering specific examples for the people and the rainforests of the Amazon and Congo basins. This author presents strategies and innovative solutions to overcome the growing threat of deforestation by embracing and using emerging technologies for a green economic and industrial revolution that meets humanity's needs while keeping planet earth healthy.

In the last decade, agroforestry has received increased recognition as an integrated approach of combined production systems involving trees and crops on the same unit of land. This has followed the ecological drawbacks and failures of high-intensity farming and forestry operations, along with the demand for environmental accountability and application of ecologically compatible land management practices both in tropical and temperate parts of the world. Agroforestry can provide ecological, economic, and social benefits, and it contributes to several environmental and development goals. Moreover, it is becoming increasingly integrated into strategies that pursue nature-based solutions for climate change (World Agroforestry Center 2019; Garrity et al. 2010; Garrity 2021) and increased sustainability (Losada 2019). As AFS provide several tree products, their adoption can lead to a reduction in human dependence on natural forests and to decreased encroachment on protected areas (Kumar and Singh 2020). These agroforestry functions work jointly toward achieving large-scale restoration goals set recently by several international organizations and agreements (Garrity 2021).

Lastly, AFS are considered a type of "environmentally benign agriculture," i.e., a type of agriculture that incorporates services of nature, using practices such as intercropping, permaculture, and regenerative agriculture (Jordan 2022; Levin 2022). Examining the efficiency of agriculture using a thermodynamic framework, Jordan (2022) explains that the most environmentally desirable types of agriculture have a high rate of return on services of nature (endosomatic inputs). They produce less pollution and are less dependent on fossil fuels (exosomatic energy). In that sense, they are more sustainable systems (Jordan 2022, 2024); however, there may be some disadvantages depending on the system's specific context (socioeconomic, cultural, political). AFS generally take several years to become established. They are often labor intensive, which is a disadvantage where labor is expensive and fossil fuel energy is cheap, but an advantage where the opposite is true. They can be less profitable for the farmer than agriculture highly dependent on energy subsidies, but more profitable for society that does not deal with agricultural pollution and other environmental consequences of conventional agriculture.

2 Past and Current Emphasis in Agroforestry Research and Practice

Worldwide, terrestrial landscapes are being impacted by unsustainable management practices in agriculture, forestry, and other human activities, as well as by climate change and subsequent chains of events. Sustainable techniques geared to harmonizing ecosystem productivity and conservation can contribute to mitigating or reversing detrimental effects on landscapes. However, degraded landscapes usually exist in a complex mosaic that is constantly changing. In response, dynamic land use designs and management strategies are needed to overturn these trends. Among these strategies, agroforestry systems (AFS) are becoming increasingly relevant worldwide, as society has come to recognize their multiple roles and services: biodiversity conservation, carbon sequestration, adaptation and mitigation of climate change, restoration of degraded ecosystems, and tools for rural development.

It has often been claimed that agroforestry is just “a new name for an old practice.” To most people, the word “agroforestry” sounds like a combination of agriculture and forestry, which is indeed the essence of agroforestry, no matter how it is defined (Nair et al. 2021). Cultivating trees in combination with crops and animals is an ancient practice historically reported in various parts of the world (Nair 1989; Nair et al. 2021). Certain types of agroforestry, such as tropical homegardens, are reported to have been associated with humans since around 10,000 BC (Kumar and Nair 2006). Nair et al. (2021) dedicate a full chapter to the historical developments and “The Coming of Age of Agroforestry” with detailed descriptions of the processes leading to what we now consider “modern” agroforestry. Over the past four decades, agroforestry has evolved gradually from modest early beginnings to an integrated approach to land management drawing upon the science-based advances in related fields (Nair et al. 2021).

Although AFS have been traditionally practiced by humans for centuries, they caught the attention of academia in the 1970s–1980s. They became a new subject of study in the pressing pursuit of alternatives to increase agricultural productivity, improve degraded soils, and favor small landholders, especially in the more impoverished rural regions of the tropics worldwide. During the 1950s and 1960s, policymakers thought the best solution to feed the world was to promote the model of intensive monocultural production systems, which had seen success in the industrialized world (Nair et al. 2021). During the second part of the twentieth century, along with remarkable growth in the human population, boosts in agricultural productivity were brought along by the “green revolution,” which included growing monocultures of genetically improved crops and intensive use of agrochemicals. However, the environmental consequences of such developments and the marginalization of smallholder farmers spurred a search for more viable alternatives for rural development.

Agroforestry garnered increased attention and recognition with the creation of ICRAF, the International Center for Research in Agroforestry (currently the World Agroforestry Center, https://www.worldagroforestry.org) in 1977, under the umbrella of the Consultative Group on International Agricultural Research (CGIAR) system (www.cgiar.org). Likewise, agroforestry became the centerpiece of many rural development projects and programs managed by several international, regional, and local institutions. These organizations sought to contribute toward solutions for the issues of rural development in a sustainable manner. Agroforestry then became the banner for addressing the food production problems of small farmers of the tropics. The practice required low inputs while simultaneously performing other beneficial functions, such as helping to recover degraded agricultural soils.

Since then, many publications have dealt with different scientific, technical, and educational aspects of AFS. The initial emphasis of the research in AFS was to demonstrate how AFS can be a viable productive alternative to industrial agriculture. Most of the books published in this period dealt with AFS design, spatial and temporal arrangement of AFS components, and research on multipurpose tree species and their functions and products (Steppler and Nair 1987; Nair 1989; Reifsnyder 1989; MacDicken and Vergara 1990; Jordan et al. 1992; Montagnini et al. 1992; Ong and Huxley 1996; Buck et al. 1999; Huxley 1999; Ashton and Montagnini 2000, among others). Numerous "Working Papers" and other documents were also published by ICRAF and CATIE (Tropical Agriculture Research and Higher Education Center, www.catie.ac.cr) (OTS/CATIE 1986; CATIE 1999, 2001), each with their own regional emphasis (Africa/Asia, and Latin America, respectively).

In the same period, nitrogen-fixing trees and shrubs received special attention, focusing on species of *Acacia*, *Alnus*, *Albizia*, *Erythrina*, *Gliricidia*, *Leucaena*, and *Prosopis* (NAS 1979; MacDicken 1994; Gómez et al. 1995; Escobar et al. 1996; Shelton 1996; Giller 2001; Cordero and Dossier 2004; Evans and Turnbull 2004). In addition, models were developed for economic and financial evaluations of AFS, as well as for estimations of soil impacts and for system-specific designs (e.g., Ramakrishnan 1992; Sullivan et al. 1992; and Young 1997).

By the turn of the millennium, agroforestry research had shifted focus toward helping to alleviate poverty and improve food security, responding to increasing environmental and rural development issues worldwide (Garrity 2004; CGIAR 2012; Nair and Garrity 2012; Montagnini et al. 2015a; Nair et al. 2021). In the last decade, emphasis has been placed on AFS' role in contributing to climate change adaptation and the mitigation of greenhouse gas emissions through fixation of atmospheric carbon (Montagnini and Nair 2004; Montagnini 2005; Palm et al. 2005; Nair et al. 2010; FAO 2012; Nair and Garrity 2012; Montagnini 2015; Montagnini et al. 2015a; Garrity 2021; Nair et al. 2021).

3 Agroforestry Systems: Compromise Among Productive and Environmental Functions

It has been estimated that AFS cover about 1000 million hectares worldwide (Zomer et al. 2009, 2014, 2016; Nair et al. 2010; Somarriba et al. 2012). This estimate is based on percent tree cover in agricultural land, and for this purpose, AFS are assumed to comprise agricultural land which contains 10–30% tree cover (Zomer et al. 2009, 2014, 2016; Montagnini and Metzel 2017, 2024). Nair et al. (2021) offer a comprehensive classification of AFS across the globe, describing schemes based on a system's structure (nature and arrangement of components), ecological distribution (rainfall, elevation), socioeconomic characteristics (subsistence, commercial), functions, and other criteria. There is no single universally applicable scheme for the classification of AFS. Several models are useful for specific situations. They are generally simpler for temperate than for tropical regions, and each model has limitations for universal applicability. The structural and functional aspects of the system provide a logical and purpose-oriented criteria for classification (Nair et al. 2021).

The most frequent AFS are shaded annual and perennial crops, silvopastoral systems, live fences, and windbreaks. Traditional and more modern multistrata AFS, such as homegardens and successional agroforestry designs, provide households with food sources, fuelwood, and high-value products to generate cash (Lok 1998; Kumar and Nair 2006; Montagnini 2006; Montagnini et al. 2015a, b; Montagnini and Metzel 2015; Bertsch 2017, also in this volume; Young 2017, also in this volume). Homegardens perform important aesthetic, social and cultural functions and can be biodiversity islands as well (Negret et al. 2022). They are also prevalent in temperate regions, both in urban and in rural settings (Toensmeier 2007, 2013, 2017, 2022, also in this volume).

Perennial crops such as cacao, coffee, yerba mate, and guayusa gain considerable advantage in terms of quality of products and system sustainability when grown in AFS (Rapidel et al. 2015; Virginio Filho et al. 2015, 2021). When designed and managed as organic, they yield products which can obtain more favorable market prices (Eibl et al. 2015, 2017, 2024; Jarrett et al. 2017, 2024).

More than 80% of rural people in the developing world still depend on fuelwood for cooking and warmth (Angelsen et al. 2014; FAO 2015). AFS can play a role in supplying fuelwood energy and facilitating the provision of other sources of energy, thus avoiding forest cutting for fuelwood (Marlay 2015; Berg 2017, also in this volume).

Silvopastoral systems (SPS), when properly designed and managed, can provide short-term income from cattle products as well as long-term returns from the trees, helping diversify investments (Murgueitio et al. 2009, 2011; Colcombet et al. 2015; Murgueitio et al. 2015; Roberts 2017, also in this volume). SPS can also provide a full set of environmental benefits and services, including climate change adaptation and mitigation (Montagnini et al. 2013; Chará et al. 2015, 2017, 2024, this volume; Peri et al. 2017, 2024, Roberts this volume) as well as biodiversity conservation (Calle et al. 2017, 2022; Calle et al. this volume; Montes-Londoño 2017, also in this volume; Montes-Londoño et al. 2022; Laino et al. 2022; Santos-Gally and Boege 2022).

Live fences, windbreaks, and riparian buffer strips are complementary AFS that contribute to connectivity in fragmented agricultural landscapes (Gordon and Newman 1997; Schroth et al. 2004; Batish et al. 2007; Francesconi and Montagnini 2015; Giraldo et al. 2022; Montagnini and del Fierro 2022, also in this volume). In general, trees on farms (TonF) and trees outside the forest can both improve livelihoods at the household level and result in positive impacts at the landscape level, for instance, through biological connectivity and regulation of the hydrological cycle (Somarriba et al. 2017, also in this volume). The chapters in this book include more detailed descriptions of the design, components, species, and functions of most of these AFS.

Currently, AFS are considered a land use that can achieve a compromise among productive and environmental functions. Among the latter, potential AFS contributions to the recovery of ecosystem and landscape attributes have gained special attention. In particular, they contribute to the restoration and conservation of biodiversity, connectivity between fragmented landscapes, and maintenance of watershed hydrological services (Mc Neely and Scherr 2003; Schroth et al. 2004; Chará and Murgueitio 2005; Jose and Gordon 2008; Redondo Brenes and Montagnini 2010; Montagnini et al. 2011; Montagnini et al. 2015a, b; Nair and Garrity 2012; Calle et al. 2013; USDA 2020; Montagnini and del Fierro 2022). Moreover, AFS can act as biodiversity islands, which are areas of high biodiversity within ecologically degraded or threatened, human-dominated landscapes (Levin 2022; Montagnini 2020; Montagnini and del Fierro 2022, 2024; Montagnini et al. 2022).

AFS are also playing an important role as part of the so-called climate-smart landscape approaches that simultaneously embrace mitigation and adaptation policies and programs (FAO 2012; Somarriba et al. 2017, also in this volume; Losada 2019; World Agroforestry Center 2019). Such landscape approaches can also represent alternatives to REDD+ (reducing emissions from deforestation and degradation) programs (Van Noordwijk et al. 2015).

In spite of the functions that AFS can provide, challenges remain for AFS implementation and adoption at scale. Several Indigenous communities manage AFS using techniques that include residue management and ash deposition. These practices enhance nutrient recycling and conservation and maintenance of high species diversity, which all promote agroecosystem sustainability (Montagnini and Jordan 2005; Montagnini 2006; Montagnini and Metzel 2015; Rocha et al. 2017, also in this volume). However, some of these communities remain marginalized, and poverty and resource degradation prevail despite the use of AFS. AFS can play a significant role in rural development even in the most challenging socioeconomic and ecological conditions, helping smallholder farmers attain higher productivity and sustainability. Nevertheless, these achievements do not always translate into significantly larger financial returns to farmers due to difficulties in the value chain of the AFS products and access to the right markets (Ormsby Mori et al. 2017; Ormsby Mori and Grover 2024; Pepper and De Freitas Navegantes Alves 2017, also in this volume; Jarrett et al. 2024).

The chapters of this book examine these challenges and offer innovative conceptual frameworks, case studies, and alternatives for implementation and management of AFS to contribute towards these goals.

4 Agroforestry Research for Development: Challenges and Alternatives

Many international institutions, government agencies, foundations, nongovernment organizations (NGOs), and others are conducting research for development geared toward decreasing rural poverty and hunger while maintaining landscape integrity and ecosystem services (CGIAR 2012; Gitz et al. 2021, 2022). Considerable funding is spent in projects to enhance productivity and sustainability of smallholder forestry and agroforestry practices, including food security and nutritional benefits, through better management of production systems.

These projects and programs face many questions and challenges, for example: How can they integrate the traditional knowledge of smallholders with scientific knowledge on environmental and agricultural strategies to promote the most suitable systems for each situation? How can barriers be removed to smallholders to access markets for tree and other AFS products, allowing them to capture more of their value, especially for people who are socially or economically marginalized (including women)? What types of products and markets are most suitable, and what interventions are most cost effective to realize these outcomes? Can successful cases of AFS be scaled-up and scaled-out to reach the target population outside the areas or regions affected by individual projects and programs?

These complex questions need innovative approaches from varying perspectives and knowledge bases. A paradigm shift is needed (López et al. 2017, 2024): for example, diversification of tree-crop commodity systems (for coffee, cocoa, oil palm and others) is key to environmental and social sustainability. This must occur in hand with innovation in market-based agroforestry and forestry systems, as shown with examples from several locations worldwide.

This book gathers fresh and novel contributions to provide alternative and sometimes departing insights into these pressing questions. The book focuses on the functions that AFS can provide when well designed and implemented. Specifically, it delves into their role in rural development, as they can improve food security and sovereignty while contributing to the provision of energy needs to smallholders. In addition, it focuses on AFS' environmental functions: contribution to biodiversity conservation, to increased connectivity of fragmented landscapes, and to adaptation and mitigation of climate change.

The chapters present conceptual aspects and case studies ranging from traditional to more modern approaches and from tropical to temperate regions of the world, with examples of the AFS functions mentioned above. Part I is dedicated to describing the main agroforestry challenges and alternatives with case studies from tropical dry, humid, and temperate ecosystems. Part II is dedicated to explaining how agroforestry systems were practiced by Indigenous communities in a variety of settings and how they can transition from subsistence to market-oriented systems. For this transition to be successful, ecological, Indigenous, and scientific knowledge must be integrated into modern agroforestry practices, enhancing opportunities to formulate tools for sustainable development and adapt Indigenous agroforestry systems for integrative landscape management and sustainable value chain development. Part III is dedicated to the multiple environmental services that agroforestry can provide in multifunctional landscapes.

From the lessons learned, the Conclusions chapter poses questions and challenges with suggestions for alternative approaches. It also deals with economic problems and barriers that limit the large-scale adoption of agroforestry systems and gives suggestions to overcome these hurdles.

Development agencies that encourage the integration of developing countries into the world economy have long supported industrial agriculture rather than organic or traditional methods, sometimes resulting in the marginalization of traditional societies (Jordan 2024). More recently, agencies are favoring projects that employ a wide variety of approaches and are more environmentally and culturally friendly, focusing not only on development but on biodiversity conservation and poverty reduction as well. Substantial policy, institutional and professional reform need to happen, with tariffs directed so that farmers in developing countries can compete in world markets and produce in a more environmentally friendly manner.

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