Historical Developments: The Coming of Age of Agroforestry

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Abstract

This introductory chapter traces the historical evolution and development of agriculture and forestry as separate disciplines and chronicles how the demands and challenges of the post-World War II era led to the emergence of agroforestry as an interface between the two. The Green Revolution technologies of the late 1900s paved the way for increasing food crop production substantially in developing countries. On the forestry front, significant gains were attained in enhancing commercial timber production through the establishment of tree plantations. However, these successes were beyond the reach of vast numbers of resource-poor farmers, and the traditional, combined production systems of trees and crops that those farmers have been practicing over generations in many parts of the world were ignored or bypassed. At the same time, tropical deforestation and its disastrous consequences continued unabated. To address these issues, agroforestry was conceived as an integrated approach to combined production systems involving trees and crops on the same unit of land. Parallel to these developments in the tropics, the importance of such combined production systems was recognized in the temperate regions as well following the ecological drawbacks and failures of high-intensity farming and forestry operations. The demand for environmental accountability and application of ecologically

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compatible land-management practices increased when it became clear that the land-use and land-cover changes associated with the removal and fragmentation of natural vegetation for the establishment of agricultural and forestry enterprises led to adverse ecological consequences. Over the past more than 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.

1.1 Introduction

In land-use parlance, the adage "a new name for an old practice" may not fit in as well for anything else as it does for agroforestry. To most people, the word agroforestry will sound like a combination of agriculture and forestry. Indeed, that is the essence of agroforestry, no matter what the definition(s) and elaborate characterizations of the term are.

1.2 Cultivating Trees and Crops Together: An Age-Old Practice

Cultivating trees and crops in combination with one another is an ancient practice that is as old as agriculture itself. The so-called tropical homegardens (Chapter 7), for example, are reported to have been associated with fishing communities living in the moist tropical region of about 10 000 B.C. (Nair and Kumar 2006). The long-standing (5000+ years) social, ethnic, and religious reverence accorded to trees and recognition of trees as components of farming systems in India (perceived as agroforestry today) have been recorded in various traditional scriptures and records (Tejwani 1994; Puri and Nair 2004). In Europe, domestic animals were introduced into forests for them to feed on the understory vegetation around 4000 B.C. (Mosquera-Losada et al. 2012). Tracing the history of agroforestry, King (1987) stated that until the Middle Ages it was the general custom in Europe to clear-fell the degraded forest, burn the slash, cultivate food crops for varying periods on the cleared area, and plant or sow trees before, along with, or after sowing agricultural crops. This "farming system" was widely practiced in Finland up to the end of the 19th century and in parts of Germany as late as the 1920s.

Trees were an indispensable part of the Hanunóo farming system in the Philippines; while clearing the forest for agricultural use, they deliberately spared certain trees, which, by the end of the rice-growing season, provided a partial canopy of new foliage to prevent excessive exposure of the soil to the sun, and provided food, medicines, construction wood, and cosmetics (Conklin 1957). Similar farming systems have also been common in many other parts of the humid lowland tropics of Asia. In Central America, it has been a traditional practice to plant more than a dozen species of plants on plots no larger than one-tenth of a hectare. Such an intimate mixture, each with its own distinct structure, imitated the layered configuration of mixed tropical forests (Wilken 1977). In Africa, the dominant form of traditional agriculture involved growing various food crops such as tubers and yams, cereals, and vegetables together under a cover of scattered trees (Forde 1937; Ojo 1966). The Dehesa system of the Mediterranean region of Europe, especially Spain and Portugal, is a centuries-old system of extensive silvopasture (see Chapter 10, Section 10.4.2). Reports on several such examples of traditional land-use practices involving combined production of trees and agricultural species on the same piece of land – which would later be called agroforestry – are available from many parts of the world (Nair 1989). Trees were an integral part of these farming systems, and they were deliberately retained on farmlands to support agriculture. The ultimate objective of these practices was not tree production but food production.

In the light of new and convincing research insights into the ecology of intercropping and multiple cropping since the late 1960s, new efforts were initiated in studying and promoting

intercropping with tree crops, leading to efforts such as the now well-known multistory cropping (Nelliat et al. 1974). It was, however, in the late 1970s that these integrated and mostly indigenous forms of growing trees and crops/animals together were brought under the realm of modern, scientific land-use under the banner Agroforestry. Several factors contributed to the push for ecologically and socially friendly management approaches to integrated natural resource management. It started with the understanding of the undesirable environmental consequences of high-input agriculture and forestry practices that focused solely on the economic bottom line (Brown 2004). These developments, which were an integral part of the developments in the overall arena of land-use (agriculture and forestry) since the 1950s, need to be traced against that backdrop.

1.3 Developments in the Agriculture Sector

Agricultural historians may not have a unanimous opinion as to when agriculture began, but it seems there is a consensus that the transition from hunter-gatherer to "farming" happened more than 10,000 years ago. Irrespective of that, two things are clear: agriculture, as practiced today, has only remote similarities to what it may have been when it started, and today it is practiced very differently in various parts of the world. British agriculturist Jethro Tull's invention of drill husbandry (horse-drawn implements such as hoe and seed drill), in the 1730s, is often considered as the beginning of modern agriculture. But the developments during the second half of the 20th century far outweigh all the developments until then (Figure 1.1).

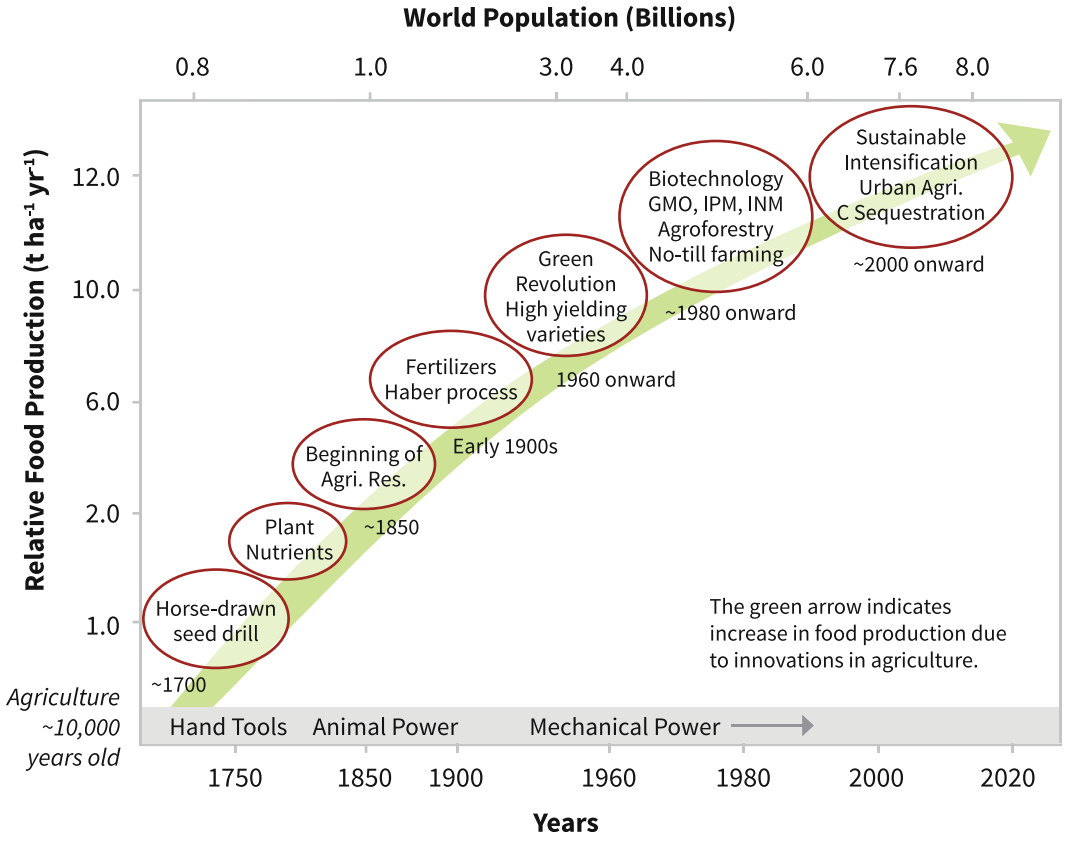

Figure 1.1 Historical developments in agriculture

1.3.1 The Green Revolution

During the second half of the 20th century, the world witnessed dramatic increases in population as well as agricultural productivity. When the newly independent nations of the developing world that were liberated from the colonial yoke were faced with the problem of feeding their millions during the 1950s and 1960s, the policymakers thought the best solution would be to focus on the model of modern intensive monocultural production systems that were successful in the industrialized world. Several food-production technologies were developed with an emphasis on the production of the newly developed high-yielding varieties of cereal crops in monocultural or sole-crop stands with a heavy input of agrochemicals (fertilizers, insecticides, herbicides, etc.), mechanization and irrigation. Collectively called the *Green Revolution*, this package of technologies helped increase the world's food production and avert large-scale hunger and famine in many parts of the world during the late 1970s (Evenson and Gollin 2003; Pingali 2012). While the world's population more than doubled from 2.5 billion in 1950 to 6.1 billion in 2000, the world economy increased more than seven-fold from $ 7 trillion in 1950 (in 2001 dollars) to $ 46 trillion in 2000, worldwide. World grain production tripled from 640 million tons in 1950 to 1,855 million tons in 2000. Out of this 190% increase in grain production, only 30% was the result of increases in area under cultivation, while the remaining 160% was made possible by increases in yield per unit area (world grain yield per ha increased from 1.06 tons in 1950 to 2.79 tons in 2000), brought about by development and adoption of modern agricultural technology. Norman E. Borlaug, who was awarded the Nobel Peace Prize in 1970 for spearheading the development of the Green Revolution, famously articulated that modern agricultural technologies helped save large areas of forest land from clearing ("forest saving agriculture"). His argument was that had the 1950 production practices persisted, an additional 1.1 billion ha of land (forest) would have been needed to produce the total quantity of food grains produced (1,855 million tons) in 2000 (Figure 1.2); thus, the higher grain production per unit area brought about by new agricultural technologies helped spare 1.1 billion ha forest land from being cleared (Borlaug 2007).

1.3.2 The International Agricultural Research Centers (IARCs)

As part of the global efforts in providing the needed research support to enhance agricultural production in developing countries, a network of international agricultural research centers (IARCs) was established in different parts of the world during the late 1970s, under an umbrella organization called the Consultative Group on International Agricultural Research (CGIAR) system (www.cgiar.org). In the beginning, each IARC focused on an individual food crop or a specific ecological region that needed special attention. Thus, separate international centers were established for rice [End Note 1], maize and wheat, potato, etc.; three centers focused on three specific ecological regions, the lowland humid tropics of Africa, the acid soils of Latin America, and the arid and semiarid regions of Asia and Africa; and two centers focusing on livestock production and animal diseases. A complete list of all IARCs (15) and websites of each are available on the CGIAR website. Voluminous literature and publications on the CGIAR system and each IARC are also available.

1.4 Developments in the Forestry Sector

1.4.1 The General Pattern of Forest Resource Utilization Over Time

Forests have served as a home, a spiritual refuge (especially for followers of some religions), and a source of raw materials, since time immemorial. Over the years, forests have been cleared at varying rates in different regions of the world for agricultural and other forms of economic development (see Section 1.4.3 on Deforestation). At the same time, forests are also cherished and protected in many parts of the world for the unique environmental benefits they offer (Díaz et al. 2018). Thus,

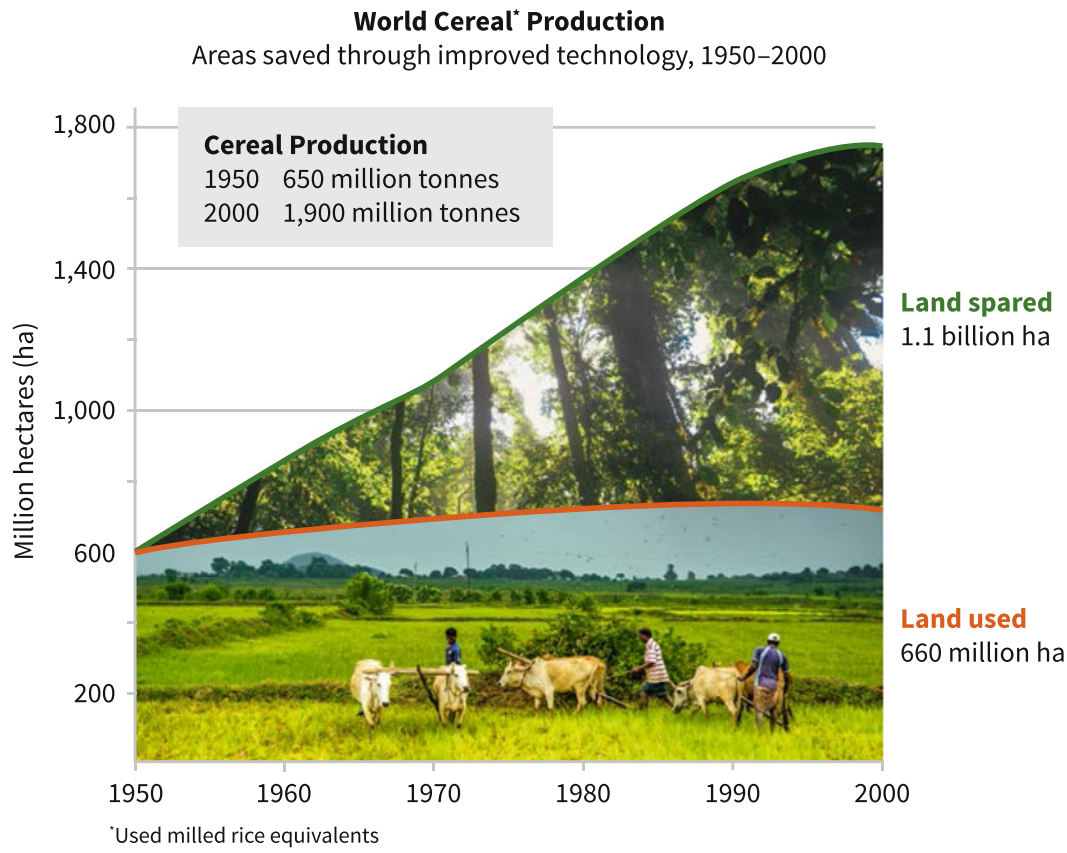

Figure 1.2 Areas saved through improved technology, as conceptualized by Borlaug (2007). The message is that the adoption of Green Revolution technology helped increase food production three-fold and reduce potential deforestation of 1.1 billion ha during 1950–2000

the relationship between humankind and the forest has "a complex and ambivalent history," as Mather (1990) puts it. According to Mather's *forest transition model*, the forest cover of any country over time may follow a U-shaped curve, implying that forested areas that experience deforestation will reach an inflection point and begin to get reforested again. This pattern of forest utilization has followed a sequential trend in different parts of the world (Figure 1.3):

- Phase I: Forests being considered an unlimited resource, with no danger of depletion or need for conservation; indeed, some reduction in the area under forest even welcomed to promote the development
- Phase II: Gradually, forest areas being converted for other uses, primarily agriculture
- Phase III: Concerns being expressed about the rapid rate of forest depletion; calls for conservation become increasingly strong and loud
- Phase IV: A phase of government action and legislative measures to arrest further destruction; the trend of destruction is either reversed or continued depending on how effectively the legislation is implemented.

Different countries have reached different stages of this model at various time-periods, and the duration of the phases vary among countries.

An excellent example of the successful operation of the model is provided by the developments in forestry in the United States during the past 500 years. When the settlers arrived in the USA, forests were abundant and were considered a hindrance to development (Phase I). Soon, forest clearance, primarily for agriculture, started vigorously (Phase II). Fears of timber famine and calls for careful management were voiced starting from the late 19th century and continued into the early 20th century (Phase III). The first Forest Act of 1891 led to the establishment of

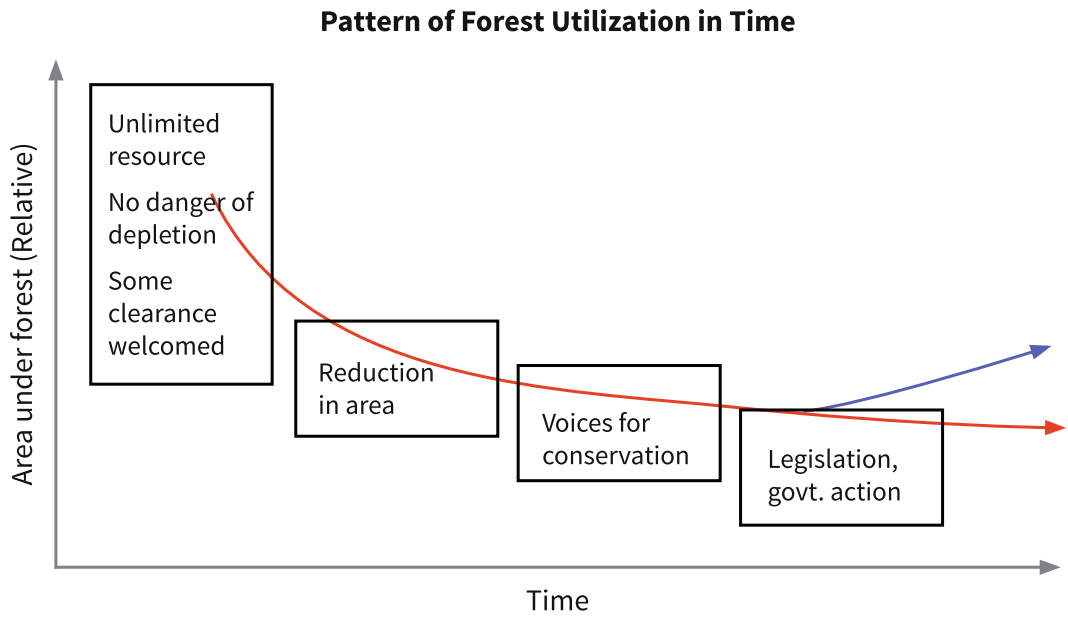

Figure 1.3 A generalized pattern of the sequential trend of forest utilization in different parts of the world
Source: Adapted from Mather (1990)

Forest Reserves (later called National Parks). Gifford Pinchot (1865–1946), the founding chief of the US Forest Service, famously stated in 1905 that "where conflicting interests must be reconciled, the question shall always be decided from the standpoint of the greatest good for the greatest number in the long run," implying the need for conservation and sustainable management of forest resources. Further, addressing the American Forestry Congress in 1905, President Theodore Roosevelt declared "if the present rate of forest destruction continues, with nothing to offset it, a timber famine is inevitable." In 1920, the US Forest Service pointed out that the logging rate was nine times the rate of growing new wood. Following the enactment and implementation of strict forestry laws and their proper implementation with the cooperation of the government, private landholders, and forest industry, the annual growth of timber exceeded the annual cut rate by 1960. This remarkable reversal is often cited as a classic example and model for other countries.

On the other extreme is the case of Greece and other Mediterranean regions, where forest destruction started more than 2000 years ago. Although laws were enacted to address the issue, they were weak, to begin with, and were not effectively implemented. Consequently, much of the original forest cover was lost and degraded beyond recovery, leaving only the scrubby vegetation of today that covers about a meager 5% of land compared to 50% 2000 years ago. Unfortunately, many developing nations, especially in Africa, are undergoing this situation of forest mismanagement and degradation today. It is important to note, however, that even when forest decline trends have been reversed, what is restored is the timber production potential of the forest; much of the aesthetic and conservation values of natural forests, once lost, cannot be restored.

The study of forests is fascinating but extremely complex, too, such that different groups of people studying and describing different aspects or components of forests and forestry come up with different perceptions, but none provides a clear, holistic picture because the whole is more than the sum of its parts. Poet

John Godfrey Saxe's description of six blind men describing an elephant is apt to portray the state of the study of forests:

> "*It was six men of Indostan, to learning much inclined,*
> *who went to see the elephant (Though all of them were blind),*
> *that each by observation might satisfy his mind.*
> *And so these men of Indostan, disputed loud and long,*
> *each in his own opinion, exceeding stiff and strong.*
> *Though each was partly in the right, and all were in the wrong!*
> *So, oft in theologic wars, The disputants, I ween,*
> *tread on in utter ignorance, of what each other mean, and*
> ***prate about the elephant, not one of them has seen!"***
> (Adapted from P. Holmgren: The new global assessments and the forest, CIFOR, Sept 2015, forestsnews@cgiar.org)

1.4.2 Major Forestry Research and Development Initiatives Since the 1950s

Although the global area under agriculture and forestry are somewhat equal (agriculture about 1.5 billion ha or 36 % of the land suitable for crop production; forestry 33%:

World Agriculture: Towards 2015/2030 – An FAO perspective www.fao.org/docrep/005/y4252e/y4252e06.htm), agriculture occupies a much more dominant position and receives a lot more attention than forestry in terms of the number of people involved, resource allocation, and research infrastructure in almost all countries around the world. The Green Revolution in agriculture signified an excellent illustration of the power of science to deal with world problems and the world community's collective response to grave challenges posed by rapid population increases and staggering food shortages in many of the newly independent states in Asia and Africa during the post-World War II era. Nothing comparable to that has happened in the forestry sector. Research and development in forestry continued to be focused on enhancing timber production, primarily through the establishment of plantations of a select few timber species and development of their high yielding cultivars and varieties as well as silvicultural practices for maximizing timber production (Figure 1.4). Except for a few prominent institutions (for example, the Forest Research Institute in Dehra Dun, India, originally known as Imperial Forest Research Institute, founded in 1906 under the British colonial rule), forestry research of any significant magnitude was not common in most developing countries. In the administrative set up too, forestry was a subset of the broad term "Agriculture" in most countries, a legacy that continues even in the international arena (Forestry is a part of the United Nations Food and Agricultural Organization – FAO).

Plantation forestry that originated in Europe and Japan around 1800 (Sedjo 2001) continues to be the main activity in forestry even today. In the tropics, teak (*Tectona grandis*), a native of South-

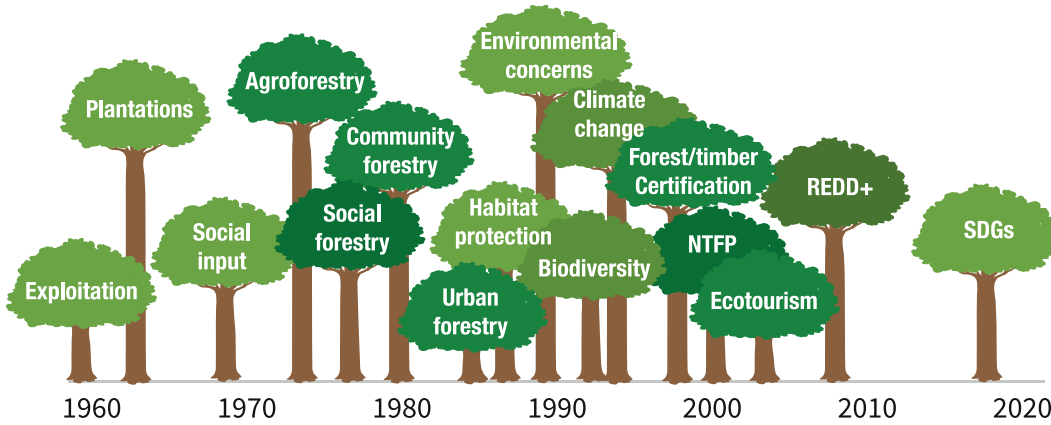

Figure 1.4 Tropical Forestry: Issues, Concerns, and Paradigms, 1960–2020

Figure 1.5 The Connolly's Plot: One of the earliest teak (*Tectona grandis*) plantations in the world. Established in the 1840s in Nilambur, Kerala, India, and declared as a permanent preservation plot by the Kerala Forest Department in 1943. (Photo: PKR Nair 2018, December)

and Southeast Asia and valued for its high-quality wood, is perhaps the first tree species to be grown in a plantation; and, the first-ever teak plantation (Figure 1.5) was established at Nilambur, Kerala, India, in 1840 (Evans 1982). According to FAO SOFA (*State of the World's Forests*) 2020 (FAO/UNEP 2020), plantations account for only about 7% of the total global forest area, but about 50% of the world's timber production. The economic importance of plantation forestry needs no further explanation. The common species grown in forest plantations are very few, with the genera *Pinus* (pines) and *Eucalyptus* being the most popular. Some exceptionally valuable tree species that are grown in plantations need a special mention here, although the area and distribution of such specialty species are relatively limited and localized. The Japanese cedar (*Cryptomeria japonica)* is one such species, valued for its special quality timber and as a hallmark of status in Japanese society, is perhaps the most intensively managed timber species in the world (Figure 1.6). Another one is the famed sandalwood tree (*Santalum album*) of the tropics, which is grown in both plantations and in association with other species; also see Chapter 13, Section 13.4.3.

By the end of the nineteenth century, establishing forest plantations had become an important strategy for practicing a land-management system called *Taungya,* considered to be one of the forerunners to agroforestry. It involved planting the preferred tree species in plantations, usually using available unemployed or landless laborers who would be looking for land to produce food and often encroaching forest land. In return for performing the forestry tasks, the laborers would be allowed to cultivate the land between the rows of tree seedlings to grow agricultural produce. The practice is reported to have originated in the 1850s in Myanmar (Burma), then a part of the British Empire (See Chapter 5 for more details).

1.4.3 Deforestation

History is replete with the harrowing tales of rich and abundant tropical forests being destroyed for their valuable timber and other natural resources by greedy dictators, leading to disastrous soil degradation and extreme impoverishment of several countries such as Haiti (Figure 1.7) and many

Figure 1.6 Japanese cedar (*Cryptomeria japonica*) plantations in Japan are arguably the most intensive silvicultural operation in the world. (Photo: PKR Nair 2000)

Figure 1.7 Deforestation: Haiti: A harrowing tale of the disastrous consequences of deforestation. The hillsides of the country, once covered with the luxurious canopy of valuable tropical timber trees have been ravaged by rampant deforestation during the early 19th century, making the country the poorest in the western hemisphere and one of the poorest in the world. (Photo: M. Bannister, 1987)

Figure 1.8 Deforestation in Kalimantan, Indonesia. (Photo: PKR Nair 1984)

nations in Africa and Asia (Figure 1.8) during the 20th century. When environmental concerns became very conspicuous on the global scene since the 1970s, deforestation of the world's tropical region attained top listing on the agenda of almost all environment-related discussions at all levels. Even today, it continues to dominate the news – both at various local and international levels ever since, with no end in sight. The recent (2020) escalation in deforestation rates of the Amazon basin of Brazil (Figure 1.9), attributed to the policy changes consequent to Brazil's administration change in late 2018 has earned widespread public outrage and condemnation the world over as reported and reverberated in all leading global news services and publications such as *The Economist*, "Deathwatch for the Amazon," 3 August 2019; and, *Time*, Special Climate Issue, 23 September 2019, Section South America, pp 68 – 87 (Figure 1.10).

Universally accepted definitions and estimates of the rates of deforestation, however, are lacking, which has added to the lack of clarity that prevailed over the discussion of these issues for so long. The World Bank defined deforestation as the disturbance, conversion, or wasteful destruction of forest lands, assembled statistics on the extent and progression of deforestation in the tropics during the 1970s and 1980s, and estimated the then prevailing rates at about 12 million hectares per year (World Bank 1991; Sharma 1992). The FAO, on the other hand, based on its preliminary estimates from the 1990 assessment, reported that the actual rate of deforestation during the 1980s was about 50 percent higher, 17.1 million hectares annually (Matthews and Tunstall 1991). One of the main reasons for these differences is that many of the assumptions, based on which estimates of the extent of tropical deforestation were made, have proven false, and very little effort has been made to update the information systematically (World Resources Institute 1990). The most widely quoted datasets of deforestation are those in the FAO's SOFO (*State of the World's Forests*) reports published periodically, the most recent one being the SOFO

Figure 1.9 Deforestation in the Amazon region of Brazil. Most discussions and reports on tropical deforestation since the 1960s start with the destruction of the Amazon forests in Brazil, which continues unabatedly at a reported annual rate of about 1% (see Figure 1.11)

Figure 1.10 Forest clearance for shifting cultivation, DR Congo. The practice of shifting cultivation (Chapter 5) is considered to be the primary reason for tropical deforestation. The photo shows a field planted with cassava (*Manihot esculenta*) and maize (*Zea mays*) in a recently burned patch of secondary forest near Yangambi, Tshopo Province, DR Congo (rainy season May 2012), with different stages of secondary forest regrowth as well as an old-growth forest in the background. Source: Pieter Moonen, http://dx.doi.org/10.1016/j.landusepol.2016.07.019 (with permission)

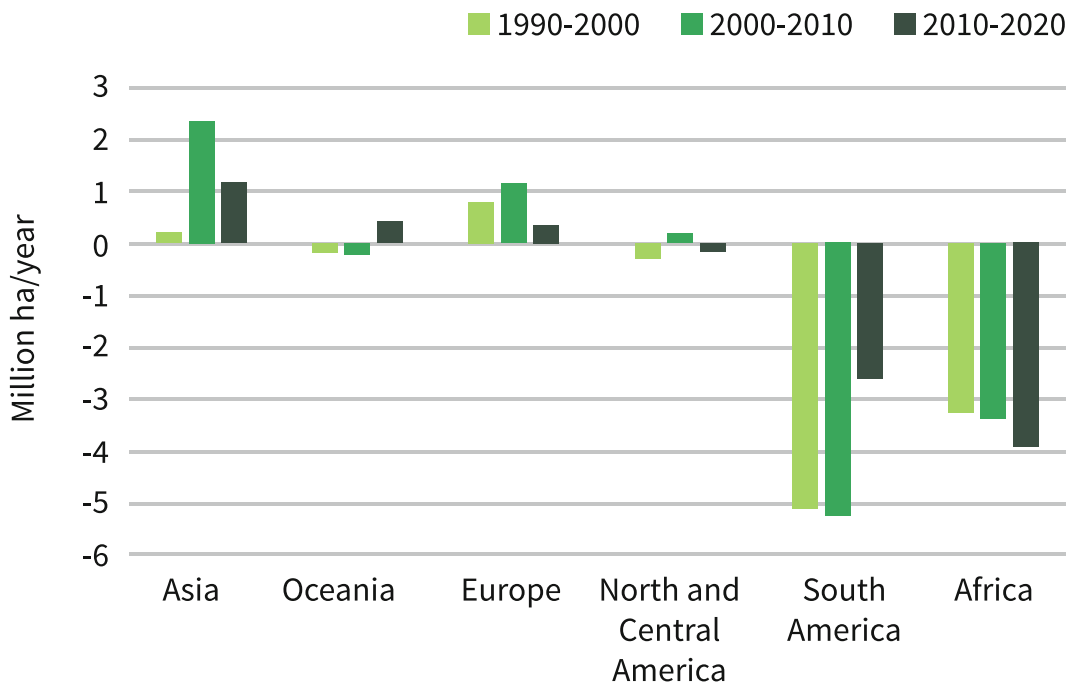

Figure 1.11 Global trends in deforestation: Changes in net forest areas, million hectares per year, in different regions of the world during 1990–2020. Source: FAO (SOFO, State of the World's Forests), 2020

2020: FAO/UNEP (2020), https://doi.org/10.4060/ca8642en. Despite the differences in estimates by different agencies, there has been no divergence of opinion that tropical deforestation rates were high in regions with large areas of remaining forests in Latin America (The Amazon Basin), Africa (Congo Basin), and Southeast Asia (Figure 1.11). The SOFO 2020 states: "*Since 1990, it is estimated that some 420 million hectares of forest have been lost through conversion to other land uses, although the rate of deforestation has decreased over the past three decades. Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. The area of primary forest worldwide has decreased by over 80 million hectares since 1990*." There has been no difference of opinion on the consequences of deforestation either: that deforestation causes a decline in the productive capacity of soils, accelerated erosion, siltation of dams and reservoirs, destruction of wildlife habitats, and loss of plant genetic diversity (World Bank 1991). It is also generally agreed that the main causes of deforestation are population resettlement schemes, forest clearance for large-scale agriculture, forestry enterprises and animal production, and in particular, shifting cultivation (see Chapter 5). As early as 1982, an FAO estimate showed that shifting cultivation was responsible for almost 70 percent of the deforestation in tropical Africa and that forest fallows resulting from shifting cultivation occupied an area equivalent to 26.5 percent of the remaining closed forest in Africa, 16 percent in Latin America, and 22.7 percent in tropical Asia (FAO 1982). The SOFO 2020 states: "*Agricultural expansion continues to be the main driver of deforestation and forest fragmentation and the associated loss of forest biodiversity. Large-scale commercial agriculture (primarily cattle ranching and cultivation of soya bean and oil palm) accounted for 40 percent of tropical deforestation between 2000 and 2010, and local subsistence agriculture for another 33 percent*."

1.4.4 People-Oriented Forestry Programs

In addition to plantation forestry, two dominant and interconnected issues impacted the directions in forestry development especially in the tropics during the second half the 20th century: the gradual acceptance and recognition of the importance of social and societal aspects of forestry (Westoby 1989) leading to the initiation of several people-oriented forestry programs, and the recognition of the increasing spread of deforestation and its devastating consequences. At the beginning of the 1970s, serious doubts and concerns began to be expressed that the basic needs of the poorest, especially the rural poor, were neither being considered nor adequately addressed in forestry development programs. Although the Green Revolution led to a substantial increase in food grains, it became quite clear and widely recognized that many of the green revolution technologies that placed a heavy demand on the increased use of fertilizers and other costly inputs were beyond the reach of resource-poor farmers in the developing countries. Most of the IARCs and the national programs focused on individual crops such as rice, wheat, maize, and potato[End Note 1], and production technologies for monocultural or sole-crop production systems of these crops. However, the farmers, especially the poorer ones, often cultivated their crops in mixed stands of more than one crop, and sometimes crops and trees; in such circumstances, the production technologies developed for individual crops would seldom be applicable. These shortcomings were recognized widely, especially by influential policy-makers. For example, Robert McNamara, the President of the World Bank confronted these concerns quite clearly when he wrote (McNamara, 1973): *"Of the two billion persons living in our developing member countries, nearly two-thirds, or some 1.3 billion, are members of farm families, and of these are some 900 million whose annual incomes average less than $100…for hundreds of millions of these subsistence farmers life is neither satisfying nor decent. Hunger and malnutrition menace their families. Illiteracy forecloses their future. Disease and death visit their villages too often, stay too long, and return too soon. The miracle of the Green Revolution may have arrived, but, for the most part, the poor farmer has not been able to participate in it. He cannot afford to pay for the irrigation, the pesticide, the fertilizer, or perhaps for the land itself, on which his title may be vulnerable and his tenancy uncertain."* Against this backdrop, the World Bank formulated a Forestry Sector Policy paper in 1978, which was designed to assist the peasant and the ordinary farmer by increasing food production and conserving the environment as much as it helps the traditional forest services to produce and process wood (Spears 1987). At around the same time, the FAO too independently undertook a reassessment of its forestry projects and redirected its focus and assistance in the direction of the rural poor (FAO 1976). As Westoby (1989) would later express it: *"Just because the principal preoccupation for the forest services in the developing world has been to help promote the miscalled forest and forest industry development, the much more important role which forestry could play in supporting agriculture and raising rural welfare has been either badly neglected or completely ignored."* The FAO policy focused on the benefits that could accrue to both the farmer and the nation if greater attention were paid to the beneficial effects of trees and forests on food and agricultural production, and advised land managers in the tropics to incorporate both agriculture and forestry into their farming system, and "eschew the false dichotomy between agriculture and forestry" (King 1979).

While these strands of forest policy reforms were evolving independently in the leading international funding agency and the specialized agency of the United Nations, several tropical land-use experts and institutions were involved simultaneously in research efforts to support the implementation of the new policies. Notable among them was the renewed and heightened interest in the concepts of intercropping and integrated farming systems. It was being demonstrated, for example, that intercropping may have several advantages over sole cropping. Preliminary results from research in different parts of the world had indicated that in intercropping systems more effective use was made of the natural resources of sunlight, land, and water; that intercropping systems might have beneficial effects on pest and disease problems;

that there were advantages in growing legumes and non-legumes in mixed stands instead of in conventional single-species stands; and that, as a result of all these, higher yields could be obtained per unit area when multi-cropping systems were compared to sole cropping systems (Papendick et al. 1976). Building upon the success of these scientific studies, agricultural scientists began exploring with renewed interest the scientific foundations and production potential of traditional practices of intercropping in the stands of tree crops. The emergence of new management approaches such as multi-tier (multistoried) cropping with coconuts in India (Nelliat et al. 1974; Nair 1979, 1983) and shade-management and nutrient dynamics under shaded perennial species such as coffee in Central America under the initiative of CATIE (*Centro Agronónomico Tropical de Investigación y Enseñanza* = Tropical Agricultural Research and Education Center; www.catie.ac.cr), Turrialba, Costa Rica (De las Salas 1979; Budowski 1983) are examples of this. The role of trees and shrubs in maintaining soil productivity and controlling soil erosion was another major research initiative during that period (Young 1989). Livestock management experts also began to recognize the importance of indigenous tree-and-shrub browse in mixed farming and pastoral production systems (Torres 1983).

The challenges and consequences of deforestation were recognized and felt as early as the 1970s. Several studies and efforts were made to reduce the extent of deforestation and suggest alternative land-management strategies. Although the problem, unfortunately, was not contained, several seemingly sound strategies evolved. Ecologists produced convincing evidence of the positive influence of forests and trees on the stability/resilience of ecosystems, leading to the call for measures to protect the remaining forests, introduce more woody perennials into managed land-use systems, and change farming attitudes. Studies carried out by anthropologists and social scientists on farmer attitudes to improved land-use systems showed the importance of mixed systems in traditional cultures and highlighted the need to build upon these practices when developing new approaches (Conway 1985; Chambers and Carruthers 1981; Raintree 1987). These studies and revelations that started in the 1970s not only brought out several scenarios and viewpoints on a complex question, but also a crucial topic that would later become a dominant theme in international and national development paradigms: sustainability. Are modern technologies causing increasing damage to the ecological foundations of agriculture, such as land, water, forests, biodiversity, and the atmosphere? In other words, in our efforts to provide for the needs of the present, are we compromising the ability of future generations to provide for themselves: are these technologies sustainable? What lessons can be learned about sustainability from the integrated land-use systems that have traditionally been practiced in different places around the world?

1.5 Formation of ICRAF and the Institutionalization of Agroforestry

This confluence of people, concepts, and institutional changes in the 1970s provided the material and the impetus for the initiation of focused efforts on promoting the combined production of trees and crops on the same parcel of land. Although many individuals and institutions have made valuable contributions to the understanding and development of the concept, the most significant single initiative that contributed to the development of agroforestry came from the International Development Research Centre (IDRC) of Canada. In July 1975, the IDRC commissioned John Bene to undertake a study to:

- identify significant gaps in world forestry research and training
- assess the interdependence of forestry and agriculture in low-income tropical countries and propose research leading to the optimization of land use
- formulate forestry research programs which promise to yield results of considerable economic and social impact on developing countries
- recommend institutional arrangements to carry out such research effectively and expeditiously, and
- prepare a plan of action to obtain international donor support.

Bene's team concluded that top priority should be given to combined production systems that would integrate forestry, agriculture, and/or animal husbandry to optimize tropical land use (Bene et al. 1977). Their report stated: "*It is clear that the tremendous possibilities of production systems involving some combination of trees with agricultural crops are widely recognized, and that research aimed at developing the potential of such systems is planned or exists in a number of scattered areas. Equally evident is the inadequacy of the present effort to improve the lot of the tropical forest dweller by such means. A new front can and should be opened in the war against hunger, inadequate shelter, and environmental degradation. This war can be fought with weapons that have been in the arsenal of rural people since time immemorial, and no radical change in their lifestyle is required. This can best be accomplished by the creation of an internationally financed council for research in agroforestry, to administer a comprehensive program leading to better land-use in the tropics.*" In short, there was a shift in emphasis from forestry to broader land-use concepts, which were perceived as having immediate and long-term relevance.

It was apparent that despite the growing awareness of the need for information on which agroforestry systems might be effectively based, very little research was being undertaken, and whatever little that was being conducted was haphazard and unplanned. Recognizing this, the IDRC Project Report recommended the establishment of an international organization, which would support, plan, and coordinate, on a worldwide basis, research combining the land-management systems of agriculture and forestry. This proposal was generally well-received by the international and bilateral agencies. Subsequently, a Steering Committee consisting of representatives of various institutions and some experts at large was constituted to move the agenda forward (Figure 1.12) in the same way in which the establishment of several CGIAR institutions had been initiated. Following a series of consultations and discussions, the International Council for Research in Agroforestry (ICRAF) was established in 1977. In 1978, the Council moved to its permanent headquarters in Nairobi, Kenya. In 1991 it was renamed as "Centre" (instead of Council) and was formally admitted to the CGIAR Group. Today it is known as the World Agroforestry Centre or World Agroforestry (www.icraf.cgiar.org), but the acronym ICRAF, which is the term in the legal documents, stands. The establishment of ICRAF in 1977 signified the institutionalization of the ancient practice of agroforestry and the beginning of "modern" agroforestry.

By the mid-20th century, the importance of combined production systems was echoed in industrialized countries too. J Russell Smith's classical work "*Tree Crops: A Permanent Agriculture*" (Smith 1929, 1950) created a "new" wave of interest in such land-use systems. He argued that "an agricultural economy based almost entirely upon annual crops such as corn and wheat is wasteful, destructive of soil fertility and illogical" (see Chapter 10). However, it was not until the late 1970s to early1980s that the push for ecologically and socially friendly management approaches such as integrated natural resource management, the principles of which are encompassed in agroforestry, gathered momentum. It started with an understanding of the undesirable environmental consequences of high-input agriculture and forestry practices that focused solely on the economic bottom line (Brown 2004: www.earth-policy.org). Their demand for environmental accountability and application of ecologically compatible management practices increased when it became clear that the land-use and land-cover changes associated with the removal and fragmentation of natural vegetation for the establishment of agricultural and forestry enterprises led to adverse ecological consequences. Gradually, agroforestry initiatives sprung up in North America in the late 1980s (Garrett 2009). The Association for Temperate Agroforestry (AFTA: http://www.aftaweb.org) formed in 1991 has been organizing biennial conferences since then (in alternate years); the 16th was in Corvalis, Oregon, in 2019. This momentum in agroforestry has spread to other industrialized regions of the world such as Europe

PARTICIPANTS IN ICRAF STEERING COMMITTEE MEETING, AMSTERDAM, June 28, 1977

No.	NAME	No.	NAME	No.	NAME
1	A. Samper	13	J.G. Bene, IDRC	24	J. Groulez, CTFT
2	E. Troeleman, RTI	14	translator	25	G.J. Vervelde, Neth.
3	J.H. Hulse, IDRC	15	L. Marcano, Ven.	26	G. Lessard, IDRC
4	W.A.C. Mathieson,UNDP	16	D. Dumith, Ven.	27	R. Olembo, UNEP
5	K. Soels, Netherlands	17	E.Giordano, Italy	28	A. Pieters, Belgium
6	T. Chandler, IDRC	18	D.F. Peterson,USA	29	G. Koopman, RTI
7	T.J. Marlay, IDRC	19	M. Mensah	30	J.G. Ohler, Neth.
8	J.C. Madamba	20	P.K.R. Nair	31	K.F.S. King, FAO
9	P. Ladouceur, CIDA	21	R. Pasquier, Swit.	32	J. Wassink, RTI
10	H. Kruijssen, Neth.	22	G.Winckler, Germ.	33	S. Appelqvist,Finl.
11	translator	23	B. Nottola, Italy	34	H. Huffnagel, RTI
12	H.W. Beall, IDRC				

Figure 1.12 ICRAF Steering Committee Meeting 28 June 1977. The creation of ICRAF (International Council – *later renamed as Centre* – for Research in Agroforestry), now called World Agroforestry, marked the institutionalization of agroforestry and initiation of agroforestry research on a global stage. PKR Nair, the primary author of this book, is in the back row, circled

(European Agroforestry Federation, EURAF, www.eurafagroforestry.eu: Riguero-Rodrigues et al. 2008; Mosquera-Losada et al. 2012) and Australia (Agroforestry.net.au: George et al. 2012) and New Zealand (Knowles 1991).

Following or along with these international efforts, several programs in agroforestry research, education, and development were initiated in various countries and regions. Agroforestry has been a major focus of activities of CATIE, Costa Rica, since the late 1970s; although focused primarily on the Central American region, CATIE has, over the decades, attained a prominent global leadership role in agroforestry research and development. Several countries have their national programs in agroforestry as well. Among these, those in two large, tropical/subtropical countries, India and Brazil, in both of which agroforestry programs were initiated during the late 1970s, merit special mention in terms of the diversity of programs in various ecological regions that are available in both countries. Specific institutions dedicated to agroforestry research and development have been established in both India and Brazil under the overall federal government agencies such as the ICAR (Indian Council of Agricultural Research), ICFRE (Indian Council for Forestry Research and Education), and EMBRAPA (*Empresa Brasileira de Pesquisa Agropecuária* = Brazilian Agricultural Research Enterprise: https://www.embrapa.br). Both these countries have national policies and development programs as well as professional societies with their periodic congresses and ensuing scientific and technical publications on different aspects of agroforestry. Several other countries also have national programs and initiatives in agroforestry commensurate with their overall size and ecological spread.

Thus, from modest early beginnings in the late 1970s, agroforestry has evolved as a land management discipline over the past more than four decades. Academic and scientific programs sprang up in various institutions around the world and agroforestry is taught as a part of forestry- and agriculture-degree courses in many universities in both the developing and industrialized world. A scientific journal, *Agroforestry Systems* (publisher: Springer) exclusively devoted to research in agroforestry was founded in 1982. Besides, agroforestry research results are now published in numerous other scientific journals in agricultural, biological, social sciences, and other related fields. A series of World Congresses in Agroforestry initiated in 2004 has held four such global events at five-year intervals (Florida, USA, 2004; Nairobi, Kenya, 2009; New Delhi, India, 2014; and Montpellier, France, 2019), attended by an average of about 1,000 participants from around 100 countries each.

Today, agroforestry is not merely the handmaiden of forestry or agriculture. It is being used as an integrated land-management system particularly by smallholder farmers around the world. The well-recognized role and potential of agroforestry for food security, poverty alleviation, ecorestoration, and climate-change mitigation make it an essential component of rural development agendas at local, regional, and global scales. Indeed, agroforestry has come of age conspicuously as a science-based land-use option.

EndNote

EndNote [1]. Latin names of plants are included only to the extent deemed necessary for the proper understanding of the species. For that reason, Latin names are avoided in the text for the unambiguous names of common food crops (such as maize, potato, rice, and so on) and perennial species (such as cashew, coconut, coffee, pines, and so on).

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