Hapres | Journal of Sustainability Research

sustainability.hapres.com

Article

Farmers' Perception of Ecosystem Services from Agroforestry Practices in Kenya: The Case of Kakamega County

Sylvester Chisika [1], Juneyoung Park [2], Hyemin Park [1], Chunho Yeom [1,*]

[1] International School of Urban Sciences, University of Seoul, Seoul, 02408, Korea

[2] Department of Smart City Engineering, Hanyang University, Ansan, 15588, Korea

* Correspondence: Chunho Yeom, Email: chunhoy7@uos.ac.kr.

ABSTRACT

Background: Agroforests are critical for the provision of ecosystem services and for the sustainability of agricultural landscapes. However, with increasing human demand, agroforests have been declining in many regions worldwide. To reverse this trend, many "greening" measures have been developed and implemented in recent years. But, the effectiveness of these measures depends on the local farmers' perceptions, values, and reactions to the ecosystem services provided by agroforests which remain understudied in many developing countries. This study investigated the farmers' perceptions of ecosystem services provided by farmland trees and forests in Kenya using the case of Kakamega County.

Methods: The perceptions of ecosystem services or disservices were analyzed using qualitative and qualitative data from online questionnaires randomly distributed among large-, medium-, and small-scale farmers.

Results: The results from the aggregated percentage ranked scores for the perception of surveyed respondents show that more than 50% of large-, medium-, and small-scale farmers agree that agroforests are highly valued for various ecosystem services. Regulatory and provisioning services are ranked fourth and fifth for large- and medium-scale farmers. Cultural ecosystem services are ranked first for large-scale farmers, whereas supporting services are ranked first among medium-scale farmers.

Conclusions: Study findings exemplify the growing appreciation of ecosystem services provided by agroforests and associated landscapes in the country, across Africa, and globally. As such, this study suggests that greening policies, measures, and strategies need to better target farmland trees and forest conservation and further adapt to local contexts.

KEYWORDS: agroforestry; ecosystem service; farmers' perception; farmland trees and forests; sustainability

Received: 20 October 2022
Accepted: 22 December 2022
Published: 30 December 2022

INTRODUCTION

Agroforestry refers to a natural resource management system that increases a landowner's economic, social, and environmental benefits by integrating trees into farmlands [1]. It combines forestry and agricultural production techniques in a sustainable agroecological production system [2]. It is for these benefits that Kenya has embraced agroforestry. The agroforestry sector directly contributes 33% to the economy and 27% indirectly through linkages to agro-based industries. Moreover, the sector employs 40% of the population besides providing 70% employment opportunities to many rural communities [3–5].

In order to enhance the socio-economic and environmental benefits of agroforestry, the country has rolled out specific policy reforms geared towards enhancing the contribution of agroforests to the economy. In 2019, the Agricultural Sector Transformation and Growth Strategy (ASTGS) was developed with the aim of improving agroforestry, agricultural output and value addition. In the wake of climate change, the country developed the National Adaptation Plan (NAP 2015–2030) and the Kenya Climate Smart Agriculture Strategy (KCSAS 2017–2026) which documents a series of measures that target to promote agroforestry. Through the Kenya National Climate Change Action Plan 2018–2022, Kenya aims to sequester up-to 4.1 Mt CO_2e by 2030 by establishing 281,000 Ha of agroforestry 2015 and 2030. Moreover, Kenya has developed the National Agroforestry Strategy 2021–2030 with the aim of restoring agricultural productive capacity and mitigating climate change through enhanced agroforestry practices.

Despite the existence of reknown agroforestry institutions in the country, agroforests continue to be threatened, especially because of the limited information on farmers' perceptions of the agroforestry ecosystem services and disservices. There are only a few existing case studies on farm-level ecosystem services [6–8]. Moreover, the highlighted cases are largely explored from a biophysical and monetization perspective with little regard for the socio-cultural aspects. For instance, there is limited information on how large-scale, medium-scale, and small-scale farm owners rank the various ecosystem services generated by agroforests and the reasons for such socio-cultural classifications [6–8]. With growing human needs, climate related risks and associated biodiversity loss, limited information on the farmers' perceptions of ecosystem services and disservices may predispose many agroforestry resources to the threat of degradation or the risk of decline, resulting in a significant negative impact on Kenya's development targets. In this regard, there is the need for more studies on landowner perceptions of various ecosystem services generated by farmland tree resources as one of the strategies for improving their sustainable management.

It is with this backdrop that this paper seeks to explore the case of Kakamega County in western Kenya in order to contribute to the ensuing discourse on how landowners rank and perceive ecosystem services from farmlands. Kakamega County is one of the 47 devolved units which were

created following the adoption of the 2010 constitution and is the fourth most populous county in Kenya. The county has emerged in recent years as one of Kenya's "frontier economies". In the recent times, Kakamega County has been experiencing multiple environmental problems, especially deforestation, water catchment destruction, and climate change [9]. In response, the county has developed policies and institutional measures to address these challenges, including operationalizing the County Environment Committee whose mandate is to monitor the environmental and social issues of development projects by working with the relevant government authorities. The county also seeks to ensure the integration of climate change risks and renewable energy technologies into environmental assessments and county development projects besides implementing national policies on climate change [9]. To achieve these plans and in view of the growing urbanization, population growth and the need for energy, Kakamega County has prioritized agroforestry as a major land use that provides many forest goods and services.

However, the agroforestry adoption rate is minimal in a majority of sugarcane growing areas because farmers prefer to keep pure sugarcane stands [9,10]. Hence, this study seeks to elucidate the farmers' perceptions of ecosystem services and disservices provided by the agroforestry practices in Kakamega County in order to build a new understanding on how to upscale agroforestry and ecosystem services. To comprehensively address this research question, this study first reviewed the linkage between agroforests and the perceptions of ecosystem services by various land users. The overall environmental situation for the development of agroforests and the provisions of ecosystem services in Kenya were reviewed to provide a context to the selected case study. Thereafter, using random online survey questionnaire, the case of Kakamega County was explored to generate the key findings and key lessons of this study.

Perception of Ecosystem Services from Agroforests and Sustainable Development

Agroforests generate multiple benefits that contribute to sustainable development. Agroforestry practices help to maintain ecological processes and can improve ecosystem diversity thus contributing to environmental quality and long-term sustainability. As such, there is a strong interest in the need to enhance the potential for agroforestry as a way of achieving many of the sustainable development goals. The State of World's Forests Report 2022 shows that agroforestry provides one of the three tree-based pathways for environmental and economic recovery [11]. Other studies have also highlighted the environmental impacts of agroforests such as climate regulation and soil fertility [12]. One of the most important assessments that illustrate the contribution of agroforestry landscapes to societal well-being is highlighted by the framework of ecosystem services, as documented in the Millennium Ecosystem Assessment Report of 2005. Although the ecosystem services approach is widely used to inform

natural resource management policies and link ecosystem functions and human well-being, the concept has been criticized as overly simplistic and inaccurate. It often negates the human contribution to ecosystem enhancements [12,13]. However, in this paper, the authors note that these classifications help society identify, describe, and evaluate the benefits of sound policy and management actions [13–15].

Agroforestry is also linked with the achievement of various global targets through multilateral environmental agreements and commitments under the Sustainable Development Goals (SDGs), the United Nations Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), and the United Nations Framework Convention for Climate Change (UNFCCC). In the African context, agroforestry has been increasingly linked with the potential to contribute to restoring 100 million hectares of degraded landscapes by 2030 under the Bonn Challenge.

Globally, there are at least 45 million hectares of agroforestry landscapes, with global indications showing an increasing hectarage [16,17]. However, agroforestry landscapes and attendant ecosystem services continue to be threatened globally by unsustainable agricultural intensification and extensification, urbanization, and illegal logging of timber, exacerbated by population growth despite the existence and implementation of forest laws, increased enforcement of such laws, the creation of protected areas, and innovative programs such as payments for ecosystem services (PES) [17]. In addition, there are limited studies on the land users' perceptions of the ecosystem services generated by agroforests, especially farmers [18]. Moreover, the existing cases are largely explored from a biophysical and monetization perspective with little regard for the socio-cultural aspects [18]. In general, it appears there is a growing demand for incorporating social preferences in ecosystem services assessments, including those generated by agroforests. These findings reinforce the need further studies in order to re-emphasize the need for sustainable management of agroforests and hence the motivation behind studying Kenya’s case.

In this paper, we concur with reports that show that the contribution of landscapes, including agroforestry landscapes, to sustainable development and human well-being is largely shaped by the interaction between the natural assets of a landscape and the people's socio-cultural forces [19]. The ecosystem services approach has provided a widely accepted framework for evaluating the environmental benefits of forests, including agroforests, which impact various aspects of well-being by showing the linkage between landscape management and rural competitiveness, local economy, and the conditions that drive production in agricultural landscapes. From a socio-cultural perspective, landscapes, including agroforestry, affect human welfare in a range of direct and indirect positive ways that utilize the use, non-use, and intrinsic as well as extrinsic values of landscape resources [20]. Improved soil fertility—a supporting service provided by agroforests—is perceived as the high ranking and main benefit of the agroforestry landscape [20]. However, other studies have shown that agroforest ecosystem support

functions are often lowly ranked by local communities, particularly in sub-Saharan Africa. This is attributed to a lack of knowledge about supporting services, such as soil formation and nutrient recycling processes [21,22]. In general, there are a number of socio-economic variables that affect how land owners perceive ecosystem services. However, it appears that provisioning services are highly acknowledged than other services. In this paper we note that these differences in appreciation were attributed to the number of livestock, area of agricultural land, residential location, and place of origin [18–22].

Other studies show that provisioning ecosystem services from agroforests in Sub-Saharan Africa are ranked highly, especially fruits, fodder, fuelwood, poles, and timber, which are often regarded as the most important ecosystem services derived from agroforestry landscapes [23]. Interestingly, this finding is consistent with those of other studies conducted in the Amazon Basin. Additionally, the existing literature suggests that many smallholder farmers recognize the regulatory functions of agroforests in mitigating the impacts of climate change [24,25]. However, cultural ecosystem services generally lag in the supporting, regulating, and provisioning categories ranked by land users [26]. This study agrees with findings suggesting that some land users may appreciate the ecosystem services provided by agroforests, while other land users view agroforests as generators of ecosystem disservices that negatively impact society. Disservices may include; pest and disease damages, increased competition by undesired species, reduced crop yields and even nutrient loss due to run-off [27].

Agroforests are also associated with ecosystem disservices. A European perception on agroforestry found that agroforestry disservices to agriculture include a decline in yield and damage to tractors and infrastructure [19–28]. This paper calls for more perception studies and observes that human perception of services in general and disservices from landscapes is a driver of human behavior. This reality has elicited an active debate on the processes affecting such perceptions [29]. Though farmers' perception of disservices has been documented by Blanco et al. [29] as well as Ango et al. [30] and the impact of disservice on the larger society remains understudied. In addition to monetary evaluations and biophysical assessments, the importance of socio-cultural assessments in service perceptions has also been suggested [31]. Research indicates that socio-cultural evaluations are based on the assessment of ecosystem services perception, which affects the interaction between people and the environment [18–31]. Perception is associated with cognitive processes, a person's experiences, and culturally influenced processes. It also concerns people's understanding of the usefulness and contribution to well-being from certain landscape elements [32]. Managing a common pool of resources, including ecosystem services beneficial at the landscape level, depends on people's perceptions. Therefore, socio-cultural approaches to assessing ecosystem services provide a means to assess how people value specific services. It contributes to developing robust environmental

policies that include the views of local stakeholders [18–32]. With this, in hindsight, the assessment of services and disservices can support the design and development of more equitable policies that can promote better management of landscape resources, including the proper balancing of private and public goods and hence the need for this study.

Existing literature also indicates that the greatest hindrance to the development of agroforestry practices globally is the long period it takes for farmers to obtain returns [33]. While many studies have confirmed the high productivity gains from agroforestry systems, various landowners still consider them financially risky and unproductive. Considering the long duration, it takes to benefit from agroforests (3–8 years), there is a need to promote agroforestry through the strategic use of policy instruments, regulations, investments, incentives, the repurposing of subsidies, the improvement of productivity with financing, and the achievement of restoration objectives [33]. Increasingly, many countries are diligently channeling more funding for actions that protect forests, including agroforests. This trend is likely to continue in terms of both the range of products and geography. Hence, there is a motivation for regional studies that focus on the growth of agroforests to provide ecosystem services and share lessons on successful practices.

Despite the highlighted theoretical context on perceptions of ecosystem services, evaluating the landowners' sensitivities to ecosystem services associated with landscapes, including agroforestry landscapes, is a difficult endeavor because there are different conceptualizations of landscapes based on differing values attached to the environment by different societies [34]. Age and education are used as variables to explain such differences in landscape conceptualization [35]. Other socio-economic variables examined in the literature include environmental orientation, occupation, place of residence, years of residency, childhood experience, cultural background, and social context [36–40]. There appears to be a correlation between these attributes and different attitudes toward the sustainable management of landscapes [41]. Often, a person's perception of ecosystem services is related to their interest in landscape values and their perceived linkages with a wider set of possible land uses [42–44]. However, assessing the residents' perceptions of reclaimed landscapes, including agroforestry landscapes, remains a less studied issue [45]. These gaps have exacerbated the mismatch between human perceptions of ecosystem services and landscape functions and may trigger unexpected impacts [46].

In a nutshell, from this review, it can be observed that at the global level, there is a growing appreciation for ecosystem services provided by agroforests and associated landscapes, and hence, the increasing areas under these forests. However, an improved understanding of the value and ranking of ecosystem services by landowners is urgent and relevant for designing and implementing sound land management options for sustainable development. As such, in the Kenyan context, this review

raises the following questions; from the perspective of sustainable development, do ecosystem services rank equally amongst small, medium and large-scale farmers? How can the provision of agroforestry-based ecosystem services be improved for enhanced environmental quality and quality of life? To address these questions, a review of Kenya's agroforestry development matrices are hereunder reviewed in order to provide context to this study.

Agroforestry ,Ecosystem Services and Sustainable Development in Kenya

Forests, including agroforests, are a major land use type that contribute to sustainable development in Kenya (Table 1). From Table 1, grassland and cropland constitute the largest proportion of land use in Kenya, but forest land appears to have increased steadily between 2000 and 2015 (Table 1). This positive trend is attributed to the fact that forests, including agroforests, are important sources of ecosystem services that promote environmental stability and socio-economic development. The forest sector contributes an estimated USD 365 million (3.6%) annually to Kenya's Gross Domestic Product (GDP). This excludes environmental services and household energy [47]. Moreover, this economic valuation represents an undervaluation of the forest sector's contribution to the national economy due to the subsistence nature and informal marketing of most forest products and since appraisals are not based on the Total Economic Value (TEV) of forests [48]. With this insight, an assessment conducted in the Cherangany Hills, Mau Forest Complex, and Mt. Elgon ecosystems estimated that the TEV of the three water tower ecosystems was estimated to be KES 339 billion per year, translating to approximately 5.0% of Kenya's GDP in 2017. Forests are also important for supplying energy resources in the country. Existing literature shows that over 80% of Kenyan rural households rely on wood fuel derived from trees and forests, such as charcoal and firewood. It has multiplied impacts on job creation and improving livelihoods [48,49]. It will be interesting to explore whether individual landowners appreciate the importance of TEV or whether they prefer a different ranking for ecosystem services.

Table 1. Land-use area changes in Kenya ('000 Ha), 1990–2015.

Land use	1990	2000	2005	2010	2015
Forest land	4724	3557	4047	4230	4413
Crop land	9258	9661	9868	10,072	10,276
Grassland	41,522	41,654	41,496	41,080	40,664
Settlement	57	87	109	126	143
Other lands	1004	1574	1035	1044	1053
Wetlands	1472	1504	1482	1485	1488
Total area	58,037	58,037	58,037	58,037	58,037

Source: FAO [50].

As of 2021, Kenya had 12.13% of tree cover 4 [51]. It implies that the constitutional requirement in Article 69 (1 a) for the country to achieve and surpass 10% tree cover and the President's directive to meet 10% tree cover by 2022 has been met. The national forest cover rose to 8.8% in 2021 from 5.9% in 2018. These achievements involved the reclamation of over 55,000 ha of encroached forest land and the concerted efforts of and support from various partner organizations and stakeholders through the forest adoption framework. A new target to attain 30% tree cover by 2050 has been set. It is of critical importance for forest ecosystems to support ecological niches as reservoirs of biodiversity, water catchments, livelihoods, and economic development. Agroforestry has immense potential for contributing to the achievement of the 30% target. It is therefore important to explore the available agroforestry options by understanding landowner perception of ecosystem services as an intervention for sustaining the management of agroforests.

Kenya has five major types of forests: western rainforests, montane forests, coastal forests, dryland forests, and forest plantations [52]. Public forests are managed by the Kenya Forest Service, a state corporation under the Ministry of Environment and Forestry. Respective county governments are, however, responsible for supervising forests within the community and on farmlands abiding by the provisions of the 2010 Constitution.

The establishment of the International Centre for Research in Agroforestry (ICRAF) in 1978 and the involvement of various development partners in collaborative research programs marked the commencement of agroforestry development in the country. Different agroforestry practices, such as live fences, soil conservation with trees, windbreaks, fodder crops, and woodlots comprising *Gliricidia sepium* and *Grevillea robusta*, were trialed during this period.

Generally, it is difficult to identify region-specific agroforest types. However, one of the oldest and most distinctive forms of traditional agroforestry is the shamba system (a form of Taunya), which was introduced during the colonial times to support the government in establishing commercial plantations [53,54]. However, due environmental activism against the Plantation Establishment and Livelihood Improvement Scheme (PELIS), a variant of the shamba system was introduced in 2007 [53,54].

The number of agroforestry stakeholders in Kenya has grown tremendously over time, resulting in various practices and interventions. The Green Belt Movement (GBM), Better Globe Forestry Limited, KOMAZA, and national producer organizations, such as the Farm Forestry Smallholder Producers Association of Kenya (FF-SPAK) and Kenya Tree Growers Association (KETGA), have undertaken extensive agroforestry work in the country [55]. These organizations are lobbying and advocating for a better policy environment for agroforestry development. Moreover, agroforestry is now accepted as a land use approach in Kenya, building upon decades of research by Kenya's seven universities offering

agroforestry either as a diploma or degree course or as a unit in one of the degree courses, which further reveals how significantly the discipline has grown in the past four decades.

To sustain the highlighted agroforestry gains at the national level, various policies, legislations, and strategies for the promotion of agroforestry have been reviewed and developed. For instance, the constitution of Kenya 2010, which introduced 47 devolved governments in the country, requires that the country maintains a minimum of 10% tree cover. In addition, the country's development blueprint, Vision 2030, prescribes a minimum tree cover of 10%. However, the recently developed Kenya National Agroforestry Strategy for the period 2021 to 2030 is more deliberate. This strategy provides immense opportunities to expand agroforestry in the country as it creates a pathway through which a bridge is created between the actors (the government, private sector, development partners, and communities in agroforestry. There is a high likelihood of the implementing this strategy for two reasons: (1) it was being implemented at a time when the country was gearing up for the August 2022 general elections with front-running parties prioritizing agroforestry development, and (2) the strategy is timed for implementation during the UN Decade on Ecosystem Restoration 2021–2030, which will place Kenya ahead in the agenda of "Preventing, halting and reversing the degradation of ecosystems" (UN/RES/73/284). It is also important to sustain the agroforestry gains made at national level because Kenya has a long-standing commitment to promote sustainable development. Whereas the 17 sustainable development goals represent responses to many intertwined global challenges, Kenya considers these goals as relevant for transformative impacts on quality of life as they are similar to the aspirations of Kenya's Vision 2030; the blueprint development strategy for the country. The country has prioritized the implementation of Sustainable Development goals and has been submitting voluntary national reports to the sustainable development governing council since the year 2016.

Kenya is also a party to various international commitments and agreements that promote agroforestry and sustainable development, such as the UNCBD and Agenda 2030. Under the Africa Landscape Restoration Initiative (AFR100), the country has committed to restoring 5.1 million ha by 2030, with agroforestry potentially restoring 1.9 million hectares. Other commitments that Kenya has ratified include the reduction of 11 million tons of greenhouse gas emissions every year up to 2030 from the forest sector as an obligation to the Paris Climate Change Agreement. This will require huge investments in the restoration of degraded landscapes and new afforestation and reforestation programs, including agroforest restoration. The other commitment is Land Degradation Neutrality (LDN) by 2030 as a contribution to the United Nations Conference to Combat Desertification (UNCCD) and the United Nations Framework Convention on Climate Change (UNFCCC) and its

Paris Agreement, which identifies forestry, including agroforests, as a key vehicle for delivering global climate change goals.

From this review, it is evident that agroforests are highly valued in Kenya for the country's socio-economic transformation. Robust policies measures have been developed to promote sustainable management of agroforests. However, there is an urgent need for studies on the perception of benefits from agroforestry as a way of scaling up agroforestry. Further studies will increase the awareness of the need for conservation of agroforests through several interventions, such as the total valuation of ecosystem benefits that these forests generate, to increase their appreciation and contribute to truly transformative development in the country.

MATERIALS AND METHODS

Study Area: Kakamega County

Location, size, and population

Kakamega County, located in western Kenya, covers an area of 3051.3 square kilometers. The county has an estimated population density of 682, with fewer males (48%) than females (52%). The population is projected to grow by 2.5% per annum. The county is divided into 12 sub-counties, 60 wards, 187 village units, and 400 community administrative areas. Politically, it comprises 12 constituencies and 60 wards [56]. The location map is shown in Figure 1.

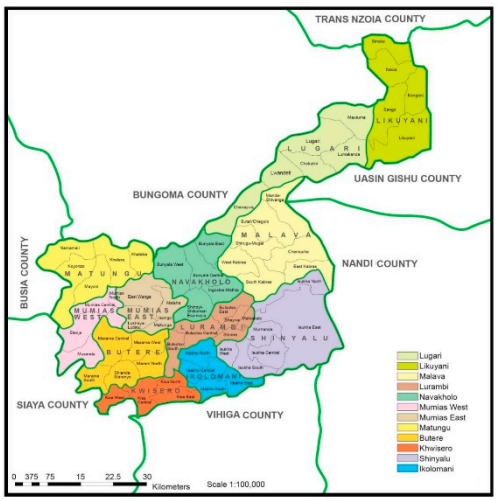

Figure 1. Location map for Kakamega County. Source: [55].

Climate and land use

The climate of Kakamega County is conducive to animal rearing and crop production. Kakamega County has 545,806 acres of arable land and 208,211 acres of nonarable land. The urban areas constitute 63,012 acres. These lands are further classified as public, community, and private. The average farm size of small-scale farmers is 1.5 acres, while that of the large-scale holders is

10 acres. This situation is attributed to the high population density depicted in Plate 1. As of 2012, only 38.6% of the land had title deeds [56].

Energy

Wood is the most prevalent energy source in the county. Up to 79.2% of the inhabitants use wood as an energy source, against the national figure of 82.5%. In addition, 1.1% used LPG, 0.6% used biogas, 13.8% used charcoal, and 1.2% used grass/shrubs (Kakamega Multiple Indicator Cluster Survey report 2013/14). Other reports, such as the Kakamega Statistical Abstract (2015), indicate that 5.6% of the country's population uses electricity for cooking, compared to the national figure of 22.7%. Up to 92.4% use paraffin for lighting compared to Kenya's 69.5% [56].

Forestry

Kakamega County has a total of 32,713 hectares of gazetted forests. The natural forest in the county has one of the richest biological diversities, including endemic animals and plant species. The Kakamega Forest is the primary forest in this county. It is the only remnant in Kenya of the once great tropical rainforest stretching across Central Africa, also known as the Guineo-Congolian forests. Key forest products in the county include timber, fiber, fuelwood, building materials, food, medicinal plants, and animals [56].

Data Collection

This study sought to generate a new understanding of farmers' perceptions of the ecosystem services provided by agroforests. Primary and secondary qualitative and quantitative datasets were used to respond to the research aims of this study. An exploratory survey design using a simple random sampling method was adopted for this purpose. This design was appropriate for this study because surveys are cost-effective and widely used to gather factual information for decision-making [57]. Surveys are a robust and cost-efficient method for collecting descriptive data. Simple random sampling (SRS) is a sample selection method comprising the "*n*" number of sampling units. The SRS technique was used to select a sample of 399 respondents from a population of 2,079,669 people with a 95% confidence level (alpha = 0.05) using Equation 1. Caution was exercised to ensure that all the respondents belonged to different households in the study area.

$$n = N/(1 + Ne^2) \quad (1)$$

where n = sample size; N = population size; e = margin of error.

Primary data collection

Primary data were collected randomly from 200 inhabitants of Kakamega County using an online questionnaire designed on Google, where the key terms were clearly defined. In the survey, a "farmer", who constitutes the

key parameter of interest, was identified as the head of a household and could be male or female. A "farmer" was defined as a person who owns, works on, or operates an agricultural enterprise that cultivates land or crops or raises animals, including livestock and fish. Kenya's agriculture is predominantly small-scale and is carried out on farms averaging 0.2–3 ha, mostly subsistence. Small-scale operations account for over 70% of agricultural production and meet approximately 75% of the national food demand. Smallholder farming entails 70% maize cultivation, 65% coffee, 50% tea, 70% beef, and 80% milk production [58]. Medium-scale farms cover 5 to 50 hectares [59]. Large-scale farming is practiced on land averaging 50 ha for crops and 30,000 ha for livestock production. The large-scale sub-sector accounts for 30% of marketed agricultural output and involves growing commercial crops, such as sugar cane, maize, tea, and coffee [60,61]. These definitions are based on a 2006 national household survey. However, the current national agricultural policy defines small farms as 0.2 to 3 hectares, medium farms as 3 to 49 hectares, and large farms as 50 to 30,000 hectares. According to the Agriculture Sector Transformation and Growth Strategy for 2019 to 2029, even though farms in Kenya are small, generally shrinking, and becoming uneconomical, agriculture accounts for one-third of the economy. There are approximately a 4.5 million small-scale farmers, including 3.5 million crop farmers, 600,000 pastoralists, and 130,000 fisherfolk.

The survey questionnaire generated both qualitative and quantitative data used in this study. The qualitative aspects evaluated included the demographic attributes of respondents, their perception of ecosystem services generated by agroforests, and ways to improve the sustainable provision of ecosystem services for sustainable development, as shown in Supllementary File 1: Key Survey Questions Asked in Kakamega County. Ecosystem services were explored by adopting and customizing the framework for evaluating ecosystem services as developed by the Millennium Ecosystem Assessment Report of 2005, where four categories of ecosystem services (provisioning, supporting, regulating, and socio-cultural) were identified (Figure 2). These broad categories are also divided into specific ecosystem services, as shown in Figure 2.

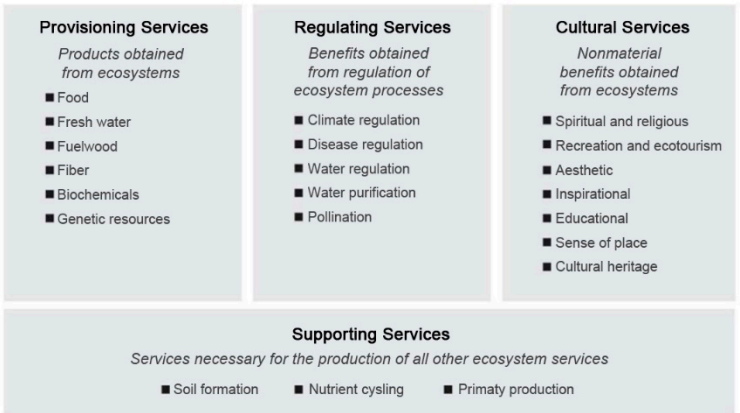

Figure 2. Categories of ecosystem services. Source: [62].

The ecosystem service framework (Figure 2) was then customized and integrated with a Likert scale that showed the percentage scores for the perception of different farmers for each specific ecosystem service. The broad categories of ecosystem services (provisioning, regulating, supporting, and socio-cultural) were disaggregated into specific ecosystem services, based on which key study questions were asked. Examples of key questions asked regarding provisioning services from agroforests were as follows: Do agroforests in Kakamega County generate fuelwood, the most important provisioning service? Do you agree that timber is this county's most important provisioning service provided by agroforests? A similar question format was repeated for the remaining specific ecosystem services identified in Figure 2. The perception results were recorded as "strongly disagree", "disagree", "uncertain", "agree", and "strongly agree".

Secondary data collection

Secondary data were collected using a literature review that assessed key documents and Internet searches on official websites. The secondary qualitative data collection entailed an in-depth document review targeting the country's key development policies and documents, as summarized in Table 2. This study determined whether these policy documents provided adequate anchorage for exploring ecosystem services from agroforests in Kenya.

Table 2. Key documents consulted.

Document	Information sought	Source
Blueprint Vision 2030 for Kenya [63]	Whether forests, including agroforests, are important for Kenya's socio-economic development	Vision 2030 Website
The constitution [64]	The land tenure system and how it affects agroforests	Kenya Law Reporting portal
The Draft Forest Policy [65]	The policy statements on the development of sustainable agroforestry in Kenya	Kenya Law Reporting portal
Forest Conservation and Management Act [66]	The institutions established to promote agroforestry development and the legal provisions that support the provision of ecosystem services	Kenya Law Reporting portal
National Agroforestry Strategy [67]	Whether the strategy is ambitious enough and complements, substitutes, or antagonizes the existing framework for the management of agroforests in Kenya	Internet search
Agriculture (Farm Forestry) Rules [68]	Whether the rules are ambitious enough to complement, substitute, or antagonize the existing framework for the management of agroforests in Kenya	Internet search

Data Analysis

The quantitative data generated from the survey were analyzed using Microsoft Excel. The perceptions of different categories of farmers in the country were grouped and compared according to land holding size as small scale, medium scale, and large scale. Differences in preferences for ecosystem goods and services from agroforests were evaluated using a Likert scale, and the percentage ranked scores of the responses.

RESULTS

Respondent Characteristics

The study achieved an 87% response rate after 350 survey questionnaires were completed and returned. The general respondent characteristics are shown in Table 3. Most households surveyed were male-headed (84%), with those in the age bracket 40–50 years dominating the survey at 39%. Most respondents were fairly educated, with 63% recording secondary education. Most farmers were small-scale farmers, and 59% of the total respondents were contacted.

Table 3. Respondents' characteristics.

Socioeconomic Variable		Number of Respondents	Percentage (%)
Gender	Male	297	84
	Female	53	16
	Total	350	100
Age of respondent (years)	18-28	20	5
	29-39	30	8
	40-50	139	39
	51-61	131	37
	62+	30	8
	Total	350	100
Education level	Primary	39	11
	Secondary	223	63
	Post-secondary	88	25
	Total	350	100
Type of farmer	Large scale	54	15
	Medium Scale	87	24
	Small Scale	209	59
	Total	350	100

Perception of Ecosystem Services

The perception of ecosystem services of large-scale farmers is presented in Table 4.

Table 4. Perception of ecosystem services by large-scale farmers.

Category of Service	Specific ecosystem service	Frequency of Responses (No.)					
		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Total
Provisioning	Fuelwood	1	3	7	41	2	54
	Timber	0	0	9	40	5	54
	Poles	1	1	4	39	9	54
	Fodder	1	2	13	30	8	54
	Fruits and Nuts	2	3	8	34	10	54
	Total	5	9	41	184	34	270
Regulatory	Soil erosion control	7	6	14	5	22	54
	Water infiltration	5	4	7	10	28	54
	Microclimate influence	6	5	0	8	35	54
	Flood control	4	5	5	4	40	54
	Disease/pests control	0	0	13	3	38	54
	Total	22	20	39	30	163	270
Supporting	Nutrient Recycling	2	0	3	10	39	54
	Soil formation	1	0	6	7	40	54
	Total	3	0	9	17	79	108
Cultural	Spiritual	0	0	2	20	32	54
	Recreation	0	0	7	12	35	54
	Education	0	0	3	18	33	54
	Aesthetic	0	0	5	14	35	54
	Total	0	0	17	64	135	216

Aggregated ecosystem services and percentage rank scores obtained by the large-scale farmers were collected. Based on calculated rank scores, agroforests' most common ecosystem service for large-scale farmers was cultural functions (92.1%), followed by supporting functions (88.9%). Provisioning ecosystem services was the third most important function perceived by such farmers (80.7%), while the least was regulatory

functions (71.5%). The perception of ecosystem services of medium-scale farmers is presented in Table 5.

Table 5. Ecosystem Services or a disservice by the medium-scale Holders Farmers.

Category of Service	Specific ecosystem service	Frequency of Responses (No.)					
		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Total
Provisioning	Fuelwood	3	7	7	60	10	87
	Timber	6	1	8	72	5	87
	Poles	7	3	9	70	7	87
	Fodder	5	3	0	76	3	87
	Fruits and Nuts	2	20	0	65	0	87
	Total	23	34	24	343	25	435
Regulatory	Soil erosion control	14	3	0	63	7	87
	Water infiltration	0	8	20	54	4	87
	Microclimate influence	1	14	6	60	6	87
	Flood control	2	1	10	70	4	87
	Disease/pests control	0	0	3	80	4	87
	Total	17	26	39	327	25	435
Supporting	Nutrient Recycling	1	1	0	70	15	87
	Soil formation	1	1	1	79	5	87
	Total	2	2	1	149	20	174
Cultural	Spiritual	1	1	3	78	4	87
	Recreation	2	2	4	79	0	87
	Education	1	11	2	69	4	87
	Aesthetic	0	6	6	70	5	87
	Total	4	20	15	296	13	348

The computed rank scores of medium-scale farmers were also collected. For them, the most important ecosystem services from agroforests were supporting (97.1%), followed by cultural functions (88.8%), provisioning ecosystem services (84.6%), and regulatory functions (80.9%). The perceptions of ecosystem services of small-scale farmers are presented in Table 6.

Table 6. Ecosystem Services or a disservice by the small-scale Holders Farmers.

Category of Service	Specific ecosystem service	Frequency of Responses (No.)					
		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree	Total
Provisioning	Fuelwood	0	7	2	134	66	209
	Timber	21	33	1	114	40	209
	Poles	29	26	11	100	43	209
	Fodder	34	23	20	102	30	209
	Fruits and Nuts	38	21	6	98	46	209
	Total	122	110	40	548	225	1045
Regulatory	Soil erosion control	3	10	9	118	69	209
	Water infiltration	14	17	1	100	77	209
	Microclimate influence	0	3	2	116	88	209
	Flood control	16	20	22	97	54	209
	Disease/pests control	1	0	19	91	98	209
	Total	34	50	53	522	386	1045
Supporting	Nutrient Recycling	19	30	25	102	33	209
	Soil formation	3	40	27	105	34	209
	Total	22	70	52	207	67	418
Cultural	Spiritual	27	22	10	110	40	209
	Recreation	18	15	3	120	53	209
	Education	5	17	2	115	70	209
	Aesthetic	22	10	7	120	50	209
	Total	72	64	22	465	213	836

The computed ranked scores of the opinions of the small-scale farmers were collected. The most important ecosystem service was regulatory service (86.8%), followed by cultural (81.1%), provisioning (73.9%), and finally, supporting (65.6%). The computed comparative ranked scores of the aggregated ecosystem services obtained from all farmers are shown in Figure 3. The data shows that all computed scores are more than 50%, representing high levels of agreement on the investigated ecosystem services.

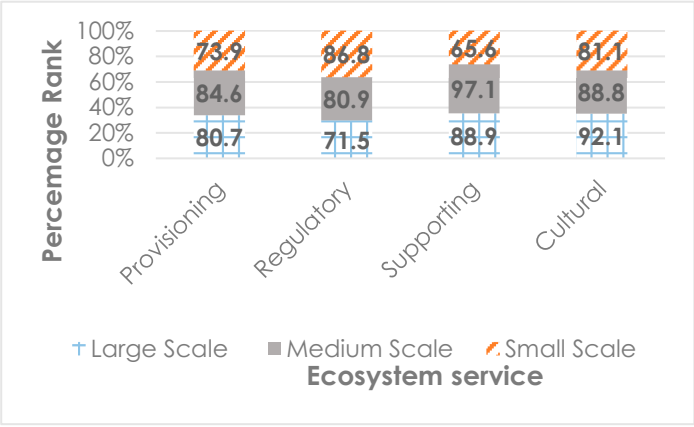

Figure 3. Percentage rank scores for the value of ecosystem services.

Improving the Delivery of Ecosystem Services from Agroforests

The respondents' beliefs regarding the greatest challenges facing the sustainable delivery of ecosystem services from agroforests are summarized in Table 7. The data shows that the biggest challenge to the provision of ecosystem services was the "non-implementation of laws and policies that promote on-farm ecosystem services", followed by "limited awareness of the importance of ecosystem services".

Table 7. Challenges to the provision of ecosystem services.

Challenges	Frequency (No.)				
	Strongly Disagree	**Disagree**	**Uncertain**	**Agree**	**Strongly Agree**
Long time it takes to achieve ecosystem services	40	14	17	79	200
Limited awareness of the importance of ecosystem services	19	35	11	120	165
Non-implementation of laws and policies that promote on-farm ecosystem services	23	1	10	86	230
Limited research and dissemination of findings on the importance of ecosystem services	15	15	8	200	112
Inadequacy of incentives and lack of repurposed subsidies	32	50	111	50	107

The farmers' perceptions regarding the improvement of the delivery of ecosystem services from agroforests are shown in Table 8. The data shows that the strategies investigated ranged from implementing laws and policies to promoting research and enhancing education and awareness of the importance of ecosystem services generated by agroforests. Promoting education and awareness of the importance of ecosystem services provided by agroforests was the most favored strategy among the farmers (88.57%), whereas providing incentives and repurposing agricultural subsidies was the least favored strategy (42.9%). Implementation of national laws and policies supporting agroforestry development was ranked second (79.14%), and establishing and strengthening institutions that promote agroforestry came in third (78.57%).

Table 8. Improving delivery of ecosystem services from agroforests.

Strategy	Frequency (No.)				
	Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
Implement laws and policies	43	11	19	78	199
Establish and strengthen institutions that support agroforestry development	29	30	16	110	165
Promote education and awareness amongst stakeholders on the importance of agroforests	22	17	1	98	212
Conduct more research and disseminate findings on the importance of ecosystem services	33	24	23	158	112
Provide incentives and repurpose the provision of subsidies	49	40	113	50	98

DISCUSSION

The purpose of this paper was to explore the case of Kakamega County in western Kenya in order to contribute to the ensuing discussion on how individual farmers rank and perceive ecosystem services from their farms. The case of Kakamega County exemplifies the fact that agroforests are important for social, economic, and environmental benefits. This finding agrees with reviewed literature which has found similar results in Kenya and other part of the world [1,16,51,52,54,62]. The results also show that the residents of Kakamega County highly value their agroforests for provision of different ecosystem services. The aggregated percentage ranked scores on the perception of respondents who agreed that agroforests are highly valued for various ecosystem services were greater than 50% for large-, medium-, and small-scale farmers. This outcome may be related to the relatively high level of education of most of the study respondents (Table 3). For large and medium-scale farmers, regulatory and provisioning services are ranked fourth and fifth, respectively. In contrast, cultural ecosystem services were ranked first for large-scale farmers, and supporting services were ranked first among medium-scale farmers.

Moreover, the results show that ecosystem support functions are the most important for both large and medium-scale farmers. This result is consistent with the existing literature, highlighting the importance of supporting functions, especially for improving soil quality and climate regulation [12,19]. Edwards et al. [12] emphasized that improved soil quality was perceived as the main ecosystem service generated by agroforests. However, these results contrast with findings from other parts of Africa, which show that local community members often have lowly ranked supporting functions due to a lack of knowledge [29,31]. Surprisingly, this finding concurs with other studies in the Amazon basin

[21]. From these findings, it is evident that due to the environmental sensitivities and challenges experienced in Kakamega County, such as poor soil quality and nutrient levels, there should be deliberate attempts to promote activities that improve soil quality, such as agroforestry.

Although the study respondents did not accord the highest priority to the provisioning role of agroforests, this study observed that these benefits are important, especially regarding the provision of fuelwood for energy in the county. It has been acknowledged in the Kakamega County CIDP [56] that wood is the main source of solid fuel for cooking in the county, with 79.2% of the county population using it as their main source of energy (Kakamega Multiple Indicator Cluster Survey report 2013/14). In the Sub-Saharan African region, the importance of wood energy is also acknowledged [56]. Provisioning functions, especially fuelwood, timber, poles, fodder, and fruits, are often regarded as the most important ecosystem services derived from agroforestry [23]. Moreover, regulatory functions are also recognized globally as important because the use of agroforestry as a mitigation measure for climate change among smallholder farmers is currently gaining relevance [23,25]. Kakamega County has also reported environmental sensitivities related to incidences of soil erosion, which is high due to the hilly terrain of the study area [56]. The climate in the region is also quite erratic. Therefore, agroforestry practices can modify this microclimate and improve human well-being. Moreover, the risk of flooding is high; thus, any act of using agroforestry technologies to control floods would be a practice that promotes the sustainable provision of ecosystem services.

Large-scale farmers ranked cultural ecosystem services as the highest, while the medium and small ones ranked them in the second position. Although this outcome contradicts the general tendency in ecosystem service assessments depicted by existing literature, where the measurement of cultural services lags behind the regulating, provisioning, and supporting services categories [26,27], this study underscores the importance of non-consumptive forest uses such as cultural use, especially tourism and educational value.

The study results also show that there are challenges to the development of agroforests which may affect the ranking and perception of ecosystem services by landowners. From survey results, there is a general perception that the non-implementation of laws and policies that promote on-farm ecosystem services is the greatest hindrance to the provision of benefits from agroforests (90.3%), and limited research (89.1%) is ranked second. Little awareness of ecosystem services was ranked third (81.4%). The long time it takes to produce ecosystem services was fourth (79.7%), and the provision of incentives and repurposed subsidies was fifth (Table 7). This study largely agrees with this ranking, given the non-implementation of the Agriculture (Farm Forestry) Rules of 2009, which outlined some of the strategies for having a robust agroforestry sector in the country. In addition, there appears to be no specific national strategic framework to facilitate building

partnerships and linkages among diverse initiatives and stakeholders to promote agroforestry practices. Successful adoption of agroforestry requires effective collaboration and partnership across sectors.

However, there are positive indications to address these challenges, as outlined in the recently unveiled National Agroforestry Strategy for the period 2021 to 2030, the Agricultural Sector Transformation and Growth Strategy (ASTGS), Kenya Climate Smart Agriculture Strategy [4]. The increasing collaboration between the growing number of local and international organizations dealing with the promotion of agroforestry and the increasing number of higher education institutions offering agroforestry studies is a clear testimony for a bright future in the sector. Moreover, the growing political goodwill of key political parties contesting in the August 2022 general elections has pledged to revitalize agroforestry. This observation is in line with the results from the case study in which the implementation of national laws and policies supporting agroforestry development was ranked second at 79.14%. The reviewed literature also echoed these strategies. However, scaling up investment will require the strategic use of policy instruments to reorient incentives and boost green markets and financing. For example, repurposing agricultural subsidies, currently almost USD 540 billion per year to include agroforestry and forestry, could help avoid the harmful impacts embodied in 86% of such subsidies [16,17].

CONCLUSION AND RECOMMENDATIONS

In conclusion, this study has demonstrated that large, medium, and small-scale farmers from Kakamega County value differently the immense ecosystem services generated by agroforests. It is highly likely that the varying opinions on reconciling the benefits of trees and forests on farmlands and agriculture largely depend on farming practices. However, the aggregated percentage ranked scores on the perception of survey respondents who agreed that agroforests are highly valued for various ecosystem services was greater than 50% across the three categories of farmers. For large and medium-scale farmers, regulatory and provisioning services were ranked fourth and fifth, respectively. In contrast, cultural ecosystem services were ranked first for large-scale farmers, whereas supporting services were ranked first among medium-scale farmers. These results exemplify the growing appreciation of ecosystem services provided by agroforests and associated landscapes in Africa and globally. Studies have shown that many agroforests are now cost-effective pathways associated with production that increases social, economic, and environmental benefits for human well-being and sustainable development. Agroforestry increases the agricultural productivity needed to hasten the achievement of many SDGs. In the Kenyan context, the case of Kakamega County has shown that agroforestry has the potential to actualize the Kenya Vision 2030 priority sectors on agriculture and livestock production in economic and social equity for a

clean and secure environment. However, there should be a concerted effort to raise awareness of the wide range of ecosystem services offered by agroforestry practices. Future studies should focus on exploring ecosystem services from a socio-cultural approach in which ecosystem services are compared depending on different agroforestry practices. The key limitation of this study was the failure to obtain a 100% response rate because it was conducted during elections in the country. Some participants felt that the survey was part of an electioneering opinion polling, due to which they were slow to provide information.

SUPPLEMENTARY MATERIALS

Supplementary File 1: Key Survey Questions Asked in Kakamega County.

DATA AVAILABILITY

All data generated from the study are available in the manuscript and from authors upon reasonable request.

AUTHOR CONTRIBUTIONS

Article conceptualization, SC and CY; methodology, SC; formal analysis, SC; investigation, SC; writing—original draft preparation, SC; writing—review and editing, JP and CY; visualization, JP and HP; supervision, HP and CY. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

FUNDING

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2020S1A5C2A01092978).

REFERENCES

1. Leakey R. Definition of agroforestry revisited. Available from: https://www.researchgate.net/publication/284100284_Definition_of_agroforestry_revisited. Accessed 2022 Dec 22.
2. Wanjira EO, Muriuki J. Review of the Status of Agroforestry Practices in Kenya. Available from: https://www.researchgate.net/profile/Erick-Wanjira/publication/353286706_Review_of_the_Status_of_Agroforestry_Practices_in_Kenya_Background_study_for_preparation_of_Kenya_National_Agroforestry_Strategy_2021-2030/links/60f1439216f9f31300878837/Review-of-the-Status-of-Agroforestry-Practices-in-Kenya-Background-study-for-preparation-of-Kenya-National-Agroforestry-Strategy-2021-2030.pdf. Accessed 2022 Dec 22.

3. Agricultural Council of Kenya. Agricultural Sector Transformation and Growth Strategy 2019–2029. Available from: https://www.agck.or.ke/Downloads/ASTGS-Full-Version-1.pdf. Accessed 2022 Dec 27.
4. Government of Kenya. National Climate Change Action Plan 2018–2022. Available from: https://napglobalnetwork.org/wp-content/uploads/2022/01/napgn-en-2022-kenya-NCCAP-2018-2022-Implemantation-Status-Report.pdf. Accessed 2022 Dec 22.
5. UNEP. Green Economy Sector Study on Agriculture in Kenya. Available from: https://wedocs.unep.org/bitstream/handle/20.500.11822/32300/GE.pdf?sequence=1&isAllowed=y. Accessed 2022 Dec 22.
6. Kinyili BM, Ndunda E, Kitur E. Influence of Agroforestry on Rural Income and Livelihood of Smallholder Farmers in the Semi-Arid Region of Sub Saharan Africa. J Trop For Environ. 2020;10(1):87-100.
7. Ouko CA, Mulwa R, Kibugi R, Owuor MA, Zaehringer JG, Oguge NO. Community perceptions of ecosystem services and the management of Mt. Marsabit Forest in Northern Kenya. Environments. 2018;5(11):121.
8. Musyoka VM. Contribution of forest provisioning ecosystem services to livelihoods of smallholder farmers adjacent Chyulu hills forest [dissertation]. Kitui County (Kenya): South Eastern Kenya University; 2020.
9. Okumu JJ, Sibiko KW, Mose PB. Drivers of perceived sustainability of climate smart Agricultural projects in Kakamega County, Kenya. East Afr Agric For J. 2022;85(3 & 4):12.
10. Liru P, Heinecken L. Building Resilience: The Gendered Effect of Climate Change on Food Security and Sovereignty in Kakamega-Kenya. Sustainability. 2021;13(7):3751.
11. FAO. The State of the World's Forests 2022. Available from: https://www.fao.org/3/cb9360en/online/cb9360en.html. Accessed 2022 Dec 22.
12. Edwards DP, Tobias JA, Sheil D, Meijaard E, Laurance WF. Maintaining ecosystem function and services in logged tropical forests. Trends Ecol Evol. 2014;29(9):511-20.
13. Comberti C, Thornton TF, de Echeverria VW, Patterson T. Ecosystem services or services to ecosystems? Valuing cultivation and reciprocal relationships between humans and ecosystems. Glob Environ Change. 2015;34:247-62.
14. Payne L. Synthesis report. Available from https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=millennium+ecosystem+assessment+Report+2005&btnG=. Accessed on 2022 Dec 22.
15. De Groot RS, Wilson MA, Boumans RM. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecol Econ. 2002;41(3):393-408.
16. Sivadas D. Pathways for Sustainable Economic Benefits and Green Economies in Light of the State of World Forests 2022. Anthr Sci. 2022. doi: 10.1007/s44177-022-00041-1
17. FAO, UNEP. The State of the World's Forests 2020: Forests, biodiversity and people. Available from: https://www.fao.org/3/ca8642en/online/ca8642en.html. Accessed 2022 Dec 27.

18. Muhamad D, Okubo S, Harashina K, Gunawan B, Takeuchi K. Living close to forests enhances people′ s perception of ecosystem services in a forest—agricultural landscape of West Java, Indonesia. Ecosyst Serv. 2014;8:197-206.
19. Targetti S, Raggi M, Zavalloni M, Viaggi D. Perceived benefits from reclaimed rural landscapes: Evidence from the lowlands of the Po River Delta, Italy. Ecosyst Serv. 2021;49:101288.
20. Chan KM, Satterfield T. Managing cultural ecosystem services for sustainability. In: Chan KM, Satterfield T, editors. Routledge handbook of ecosystem services. London (UK): Routledge; 2016. p. 343-58.
21. Pinillos Cifuentes DA, Bianchi FJ, Poccard-Chapuis R, Corbeels M, Tittonell P, Schulte R. Understanding landscape multifunctionality in a post-forest frontier: Supply and demand of ecosystem services in Eastern Amazonia. Available from: https://agritrop.cirad.fr/595005/1/Understanding%20landscape%20multifunctionality%20in%20eastern%20Amazonia.pdf. Accessed 2022 Dec 27.
22. Bardhan S, Jose S. The potential for floodplains to sustain biomass feedstock production systems. Biofuels. 2012;3(5):575-88.
23. Waldron A, Garrity D, Malhi Y, Girardin C, Miller DC, Seddon N. Agroforestry can enhance food security while meeting other sustainable development goals. Available from: https://journals.sagepub.com/doi/epub/10.1177/1940082917720667. Accessed 2022 Dec 27.
24. Mbow C, Van Noordwijk M, Luedeling E, Neufeldt H, Minang PA, Kowero G. Agroforestry solutions to address food security and climate change challenges in Africa. Curr Opin Environ Sustain. 2014;6:61-7.
25. Quandt A. Contribution of agroforestry trees for climate change adaptation: narratives from smallholder farmers in Isiolo, Kenya. Agrofor Syst. 2020;94(6):2125-36.
26. Meijer SS, Catacutan D, Ajayi OC, Sileshi GW, Nieuwenhuis M. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. Int J Agric Sustain. 2015;13(1):40-54.
27. Shackleton RT, Angelstam P, van der Waal B, Elbakidze M. Progress made in managing and valuing ecosystem services: a horizon scan of gaps in research, management and governance. Ecosyst Serv. 2017;27:232-41.
28. Rolo V, Roces-Diaz JV, Torralba M, Kay S, Fagerholm N, Aviron S, et al. Mixtures of forest and agroforestry alleviate trade-offs between ecosystem services in European rural landscapes. Ecosyst Serv. 2021;50:101318.
29. Blanco J, Dendoncker N, Barnaud C, Sirami C. Ecosystem disservices matter: Towards their systematic integration within ecosystem service research and policy. Ecosyst Serv. 2019;36:100913.
30. Ango TG, Börjeson L, Senbeta F, Hylander K. Balancing ecosystem services and disservices: smallholder farmers' use and management of forest and trees in an agricultural landscape in southwestern Ethiopia. Available from: http://www.jstor.org/stable/26269493. Accessed 2022 Dec 27.

31. Martın-López B, Iniesta-Arandia I, Garcıa-Llorente M, Palomo I, Casado-Arzuaga I, Del Amo DG, et al. Uncovering ecosystem service bundles through social preferences. PLoS One. 2012;7(6):e38970.
32. Lhoest S, Dufrene M, Vermeulen C, Oszwald J, Doucet JL, Fayolle A. Perceptions of ecosystem services provided by tropical forests to local populations in Cameroon. Ecosyst Serv. 2019;38:100956.
33. Bishaw B, Soolanayakanahally R, Karki U, Hagan E. Agroforestry for sustainable production and resilient landscapes. Agrofor Syst. 2022;96(3):447-51.
34. Soini K, Pouta E, Salmiovirta M, Uusitalo M, Kivinen T. Local residents' perceptions of energy landscape: the case of transmission lines. Land Use Policy. 2011;28(1):294-305.
35. Zube EH, Pitt DG, Evans GW. A lifespan developmental study of landscape assessment. J Environ Psychol. 1983;3(2):115-28.
36. Kaltenborn BP, Bjerke T. Associations between environmental value orientations and landscape preferences. Landsc Urban Plan. 2002;59(1):1-11.
37. Brody AL, Mandelkern MA, Jarvik ME, Lee GS, Smith EC, Huang JC, et al. Differences between smokers and nonsmokers in regional gray matter volumes and densities. Biol Psychiatry. 2004;55(1):77-84.
38. Cantrill JG, Senecah SL. Using the 'sense of self-in-place' construct in the context of environmental policy-making and landscape planning. Environ Sci Policy. 2001;4(4–5):185-203.
39. Hein L, Van Koppen K, De Groot RS, Van Ierland EC. Spatial scales, stakeholders and the valuation of ecosystem services. Ecol Econ. 2006;57(2):209-28.
40. Cebrián-Piqueras MA, Karrasch L, Kleyer M. Coupling stakeholder assessments of ecosystem services with biophysical ecosystem properties reveals importance of social contexts. Ecosyst Serv. 2017;23:108-15.
41. Smith HF, Sullivan CA. Ecosystem services within agricultural landscapes—Farmers' perceptions. Ecol Econ. 2014;98:72-80.
42. Campos M, Velázquez A, Verdinelli GB, Priego-Santander ÁG, McCall MK, Boada M. Rural people's knowledge and perception of landscape: A case study from the Mexican Pacific Coast. Soc Nat Resour. 2012;25(8):759-74.
43. Aretano R, Petrosillo I, Zaccarelli N, Semeraro T, Zurlini G. People perception of landscape change effects on ecosystem services in small Mediterranean islands: A combination of subjective and objective assessments. Landsc Urban Plan. 2013;112:63-73.
44. Geijzendorffer IR, Martín-López B, Roche PK. Improving the identification of mismatches in ecosystem services assessments. Ecol Indic. 2015;52:320-31.
45. Svobodova K, Sklenicka P, Molnarova K, Salek M. Visual preferences for physical attributes of mining and post-mining landscapes with respect to the sociodemographic characteristics of respondents. Ecol Eng. 2012;43:34-44.
46. Van der Leeuw S. For every solution there are many problems: the role and study of technical systems in socio-environmental coevolution. Geogr Tidsskr Dan J Geogr. 2012;112(2):105-16.

47. FAO. State of the World's Forests 2014: Enhancing the Socio-economic Benefits from Forests. Available from: http://www.fao.org/3/i3710e/i3710e.pdf. Accessed 2022 Aug 25.
48. Crafford J, Strohmaier R, Muñoz P, Oliveira TD, Lambrechts C, Wilkinson M, et al. The role and contribution of Montane forests and related ecosystem services to the Kenyan economy. Nairobi (Kenya): UNEP; 2012.
49. Ministry of Environment and Natural Resources. National Forest Programme 2016–2030. Available from: http://extwprlegs1.fao.org/docs/pdf/ken190060.pdf. Accessed 2022 Aug 25.
50. FAO. Kenya—Global Forest Resources Assessment 2015—Country Report. Available from: https://www.fao.org/publications/card/en/c/8017d9cc-dcba-4484-a053-7851ab3c2ccb/. Accessed 2022 Aug 25.
51. Chisika SN, Yeom C. An exploration of the connection between tree cover and selected development indicators in Kenya's devolved units. Int For Rev. 2022;24(2):145-62.
52. Ministry of Environment and Natural Resources. National Strategy for Achieving and Maintaining 10% Tree Cover by 2030. Accessed at http://www.environment.go.ke/wp-content/uploads/2019/08/Strategy-for-10-Tree-Cover-23-5-19-FINAL.pdf. Accessed 2022 Aug 25.
53. Witcomb M, Dorward P. An assessment of the benefits and limitations of the shamba agroforestry system in Kenya and of management and policy requirements for its successful and sustainable reintroduction. Agrofor Syst. 2009;75(3):261-74.
54. Kagombe JK, Gitonga J. Plantation establishment in Kenya: the shamba system case study. Available from: https://www.researchgate.net/publication/242119374_Plantation_establishment_in_Kenya_The_Shamba_System_Case_Study. Accessed 2022 Dec 27.
55. Ngome Chisika S, Park J, Yeom C. The impact of legislation on sustainability of farm forests in Kenya: the case of Lugari sub-county in Kakamega county, Kenya. Sustainability. 2019;12(1):27.
56. County Government of Kakamega. Kakamega County Integrated Development Plan 2018–2022. Available at https://repository.kippra.or.ke/handle/123456789/1132. Accessed 2022 Aug 25.
57. Nardi PM. Doing survey research: A guide to quantitative methods. 4th ed. New York (US): Routledge; 2018.
58. Government of Kenya. National climate change action plan 2013–2017. Available from: https://cdkn.org/sites/default/files/files/Kenya-National-Climate-Change-Action-Plan.pdf. Accessed 2022 Aug 25.
59. Polity. Are nearly 80% of Kenya's farmers smallholders? No data shows this. Available from: https://www.polity.org.za/article/are-nearly-80-of-kenyas-farmers-smallholders-no-data-shows-this-2019-06-06#:~:text=Kenya's%20agriculture%20ministry%20defines%20smallholder,bigger%20farms%20are%20large%2Dscale. Accessed 2022 Aug 25.

60. Route to Food. Small-scale farmers are key to food security. Available from: https://routetofood.org/small-scale-farmers-are-the-key-to-food-security-in-kenya/#:~:text=Kenya's%20agriculture%20is%20predominantly%20small,of%20the%20national%20food%20demand. Accessed 2022 Aug 25.
61. World Bank Group. Doing Business 2015: Going Beyond Efficiency: Comparing Business Regulations for Domestic Firms in 189 Economies: a World Bank Group Flagship Report. Washington (US): World Bank Publications; 2014.
62. Reid WV. Millennium ecosystem assessment. Available from: https://www.millenniumassessment.org/documents/document.356.aspx.pdf. Accessed 2022 Dec 27.
63. Vision 2030 Delivery Secretariat. Kenya's Vision 2030. Available from: https://vision2030.go.ke/about-vision-2030/. Accessed 2022 Aug 25.
64. The National Council for Law Reporting. The constitution of Kenya, 2010. Accessed at http://www.parliament.go.ke/sites/default/files/2017-05/The_Constitution_of_Kenya_2010.pdf. Accessed 2022 Aug 25.
65. Ministry of Environment and Natural Resources. Draft Forest Policy 2020. Available from: http://www.environment.go.ke/wp-content/uploads/2020/06/Draft-Forest-Policy-19May-2020-.pdf. Accessed 2022 Aug 25.
66. Republic of Kenya. Forest Conservation and Management Act, 2016. Available from: http://www.kenyaforestservice.org/index.php/download/forest-conservation-and-management-act-no-34-of-2016-2/. Accessed 2022 Aug 25.
67. CTCN. National Agroforestry Strategy 2016–2030. Available from: https://www.ctc-n.org/system/files/dossier/3b/KENYA%20AGROFORESTRY%20STRATEGY%20DRAFT%20February%202021_.pdf. Accessed 2022 Aug 25.
68. Agriculture (Farm Forestry Rules) 2009. Available from: https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2017/12/Farm-Forestry-RulesKenya.pdf. Accessed 2022 Aug 25.

How to cite this article:
Chisika S, Park J, Park H, Yeom C. Farmers' Perception of Ecosystem Services from Agroforestry Practices in Kenya: The Case of Kakamega County. J Sustain Res. 2022;4(4):e220016. https://doi.org/10.20900/jsr20220016