TREES IN SEMIARID ZONES – PERCEPTION OF ECOSYSTEM SERVICES AND COMMUNITY VALUES IN NIĞDE PROVINCE, CENTRAL ANATOLIA, TÜRKIYE

OLOWU, E. A.[1*] – RILEY, I. T.[1,2] – AVCI, M.[1]

[1]*Graduate School of Natural and Applied Sciences, Niğde Ömer Halisdemir University, Merkez Yerleşke, Bor Yolu Üzeri, 51240 Merkez/Niğde, Türkiye*
(ORCID: https://orcid.org/0000-0002-2488-5929 – Olowu, E. A.; https://orcid.org/0000-0002-3592-0785 – Riley, I. T.; https://orcid.org/0000-0003-0875-511X – Avcı, M.)

[2]*School of Agriculture, Food and Wine, The University of Adelaide, PMB 1 Glen Osmond SA 5064, Australia*

[*]*Corresponding author*
e-mail: eniolowu@gmail.com

(Received 14th Jul 2023; accepted 30th Oct 2023)

Abstract. Central Anatolia typifies the semiarid agroecological conditions of Türkiye given its low annual precipitation and winter temperatures. Wheat, barley, chickpea, lentil, vetch, apples and potatoes are largely grown in this zone but native perennials, including oaks, Turkish fir and poplar, are on the decline thereby limiting their contribution to ecosystem services. The disconnect between the value of trees and ecosystem services in Central Anatolia has not been studied previously. This study focused on the knowledge, importance, intercropping, ecosystem services, community values and planting of trees in Niğde, a representative province in Central Anatolia, Türkiye. A quantitative survey of 301 participants was conducted to understand their perception of selected trees grouped as nitrogen fixing and non-nitrogen fixing. Indicators were tested for association ($\chi 2$) and responses were disaggregated into two participant groups, farmers and non-farmers. Generally, participants showed a widespread knowledge about the trees. The top five trees of perceived importance were fruit, poplar, hawthorn, black pine and oak which were mainly valued for environmental protection, health and income. High value tree agroforestry was a preference while perception of tree-based ecosystem services focused on cultural and provisioning services. Although there was considerable support for the concept of planting more trees, tree survival remains low and increased social engagement in further perennial studies is needed.
Keywords: *agroforestry, ecosystem service, importance, knowledge, perception, value*

Introduction

The semiarid agroecological zone of Türkiye is characterized by low precipitation and temperature (Erinç and Tunçdilek, 1952) with trees uniquely adapted to these conditions through rapid taproot development and drought tolerance (Çalışkan and Boydak, 2017). Central Anatolia accounts for over half of the semiarid agroecological zone of Türkiye which extends through to Southeastern Anatolia (Cayci et al., 2009; Aydın, 2022). The Central Anatolia Region of Türkiye includes the provinces of Aksaray, Ankara, Cankırı, Eskişehir, Karaman, Kayseri, Kırıkkale, Kırşehir, Konya, Nevşehir, Niğde, Sivas and Yozgat, and has great economic and cultural importance linked to Turkish history and civilization (TCKTB, 2023). The crops mainly grown in this region include cereals such as wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) as well as legumes such as chickpea (*Circer arietinum*), lentil (*Lens culmunaris*) and vetch (*Vicia sativa*) (Cayci et al., 2009). Niğde Province is particularly

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

well known for production of apples (*Malus domestica*) and potatoes (*Solanum tuberosum*) (Bozbuğa and Pırlak, 2012; Kart et al., 2017).

With a declining population of native species such as oak (*Quercus* spp.), Turkish fir (*Abies cilicica*) and poplar (*Populus nigra*), Riley (2021) described the Central Anatolia as an anthropogenic steppe with urgent need for reforestation through agroforestry. In a study of root responses of actinorhizal plants in Türkiye, Riley et al. (2021) identified alder (*Alnus glutinosa*, *Alnus orientalis*), false hemp (*Datisca cannabina*), Russian olive (*Elaeagnus angustifolia*), sea buckthorn (*Hippophae rhamnoides*) as native species and river sheoak (*Casuarina cunninghamiana*) as the only exotic species. Actinorhizal plants are characteristic for nitrogen fixing and effective recolonizers of degraded soils hence exotic genera such as *Allocasuarina* and *Casuarina* will be useful consideration for agroforestry in Central Anatolia, Türkiye (Riley, 2021).

The merit of agroforestry using actinorhizal (nitrogen fixing) plants is based on the assumption that functional value of trees may be sufficient driver for reforestation and derivation of ecosystem services from trees. However, functional values of trees leading to provisioning, regulating, supporting and cultural ecosystem services of trees may not be sufficient drivers for agroforestry (Asbjornsen et al., 2014) if ecosystem services derived from perennials are not connected to social values of the current communities residing the area (Asbjornsen et al., 2014; Dorji et al., 2019).

Perception studies in agroforestry for semiarid are quite limited. Of the available studies, the focus had been on how tree forms were perceived by individuals (Müderrisoğlu et al., 2006), farmers' perception on vegetation changes (Wezel and Hagis, 2000), adoption of agroforestry practices (Segnon et al., 2015), tree perception in urban areas (Gerstenberg and Hofmann, 2016), perceived potential for agroforestry to thrive in semiarid (Krishnamurthy et al., 2019), perception of ecosystem services and disservices (Teixeira et al., 2019; Blanco et al., 2020), tree shelterbelts (Ruppert et al., 2020), and soil health improvement through intercropping with trees (Cyamweshi et al., 2023). Also, these studies were conducted in Africa (Wezel and Hagis, 2000; Cyamweshi et al., 2023), Central Asia (Ruppert et al., 2020), Europe (Blanco et al., 2020) and Latin America (Krishnamurthy et al., 2019) using qualitative or quantitative techniques or both. Studies of perceptions in agroforestry are pertinent to understanding the social values and norms (Fleming et al., 2019) that are behind the people's choices for agroforestry, opportunities and obstacles.

The systematic review of Başak et al. (2022) on ecosystem services studies in Türkiye provided useful insights such as most studies conducted in Türkiye focused on regulating services. However, there have been no studies on ecosystem services in Central Anatolia and despite having a high number of pragmatic studies, little consideration was given to social engagements and understanding of social values which are integral to perception of the trees. Additionally, studies have not reflected the linkages of ecosystem services to perennials differently from non-perennials. Consequently, this is a novel study that presents the case of trees in Niğde as a representative province in Central Anatolia, Türkiye from the perception of the community. The objectives of the study included knowledge assessment of the community for selected nitrogen and non-nitrogen fixing trees in their environment, perception of importance of these trees to respondents, preference for agroforestry as indicated by tree-based intercropping, perception of tree-based ecosystem services, community values and their willingness for tree planting.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Materials and methods

A perception-based quantitative survey on trees and ecosystem services was conducted among 301 individuals in Niğde Province, Central Anatolia, Türkiye. The meteorological data of Niğde Province was obtained in this study similar to the studies of Dorji et al. (2019) and Wagner et al. (2019) among others. This was pertinent to providing the context of agroecological zone of Niğde Province being the focus of the quantitative survey. Niğde is a semiarid area with less than 400 mm annual precipitation, having characteristic dry and cold winters with some minimums of -10°C or below in most years (*Figure 1*). The population of Niğde Province is about 400,000 and it has six districts Altunhisar, Bor, Çamardı, Çiftlik, Merkez and Ulukışla. (TUİK, 2020).

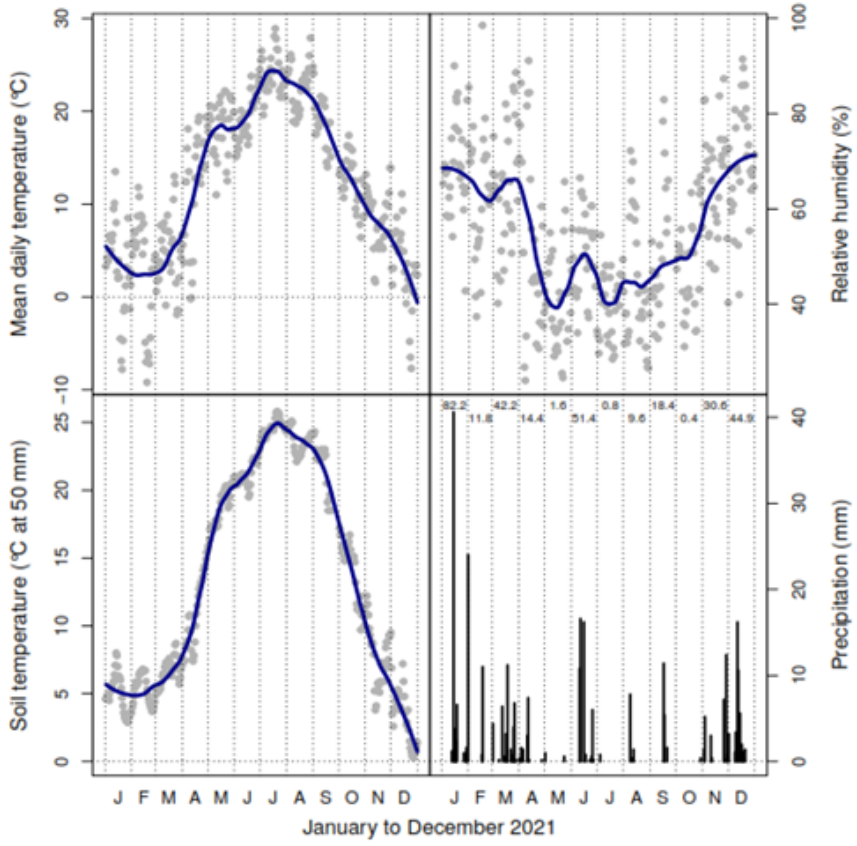

Figure 1. *A representative (2021) annual meteorological conditions in Niğde province, Türkiye (TCNMM, 2022)*

A survey instrument was developed with six factors and 10 indicators (*Table 1*) adapted from Haines-Young and Potschin (2013) and Dorji et al. (2019). Survey was administered in Turkish language to respondents that were arbitrarily selected across the six districts of Niğde. Pictures of 12 trees that were identified as relatively common or known to occur in Niğde by the authors were provided to the respondents to match with their names to determine their knowledge of the trees. These trees were alder, apple, black pine (*Pinus nigra*), black willow (*Salix nigra*), chinaberry (*Melia azedarach*), hawthorn (*Crategeus* spp.), oak, poplar, Russian olive, sea buckthorn, Turkish fir and weeping willow (*Salix babylonica*). The actinorhizal (nitrogen fixing) plants in this

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

study (alder, Russian olive, sea buckthorn) were not tagged separately from the non-nitrogen fixing plants for the respondents. This formed an additional layer of analysis to help understand if respondents' choices were linked to the functional value of the trees (their nitrogen fixing ability).

Table 1. *Factors and indicators for the study*

SN	Factor	Indicator
A	Knowledge	Tree identification
B	Importance	Connection to farm
		Connection to environment
C	Intercropping	Connection to crops
D	Ecosystem services	Connection to ecosystem services
E	Community value	Connection to people
F	Tree planting	Everyone should be involved with planting
		Planting beneficial tree should be the focus
		The willingness to plant beneficial trees in environment
		The willingness to plant beneficial trees on the farm

The perception of importance of trees to farms and environment was determined as low to high and respondents were asked of their preference to intercrop, legumes and cereals or fruits with such trees. In addition, options for perceived ecosystem services were cultural, provisioning, regulating and supporting while community values included aesthetics, culture, environmental protection, health, income, recreation, religion and wildlife habitat. The first two indicators of tree planting were assessed using a five-point Likert scale (1-5 being strongly disagree to strongly agree) and the last two as binary indicators (yes or no options).

Sociodemographics of the respondents included their gender, district class (respondent residence - rural or urban), farm owner and farm settlement (farm location - rural or urban). In this study the farmers (farm owners) were considered to have informed views on agricultural systems based on actual practice on their farms compared to the other respondents without farms. At that, no further questions to test the actual experience of the farmers on the use of the trees for intercropping and ecosystem services were asked. Prior to completing the survey instrument, signed consent of each respondent was obtained and the respondents were advised that all data collected would be anonymized before aggregation. In addition, the survey indicators were subjected to test of association ($\chi 2$), 95% confidence interval and responses were disaggregated to determine the difference in perception of farmers and non-farmers using jamovi statistical software (The jamovi project, 2021).

Results

The results presented in this paper include the sociodemographic of the respondents, knowledge and importance of the trees in Niğde province, Central Anatolia. In addition, intercropping of legumes, cereals, and fruits, with trees, tree-based ecosystem services, community values as well as tree planting were detailed.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Sociodemographics

The sociodemographics of the respondents included gender, district class (rural or urban), farm ownership and farm settlement (rural or urban). There were 56% of males and 43% females that participated in the survey. Most respondents resided in the urban districts (82%) compared to 18% in rural districts and were from a broad range of sectors. Only 16% of the respondents were farm owners (classified as farmers in this study) and the farm settlement (rural: urban) ratio was 46:54.

Knowledge, importance and intercropping

There was widespread knowledge of the trees among respondents of this study. *Figure 2* showed that non-nitrogen fixing trees such as apples (B6), black pines (B1), hawthorn (B5), oak (B7) and poplar (B8) were the most well-known. Alder (A1) was the least known tree of the three nitrogen-fixing trees (consistent with limited local occurrence) while more than 60% of respondents could identify Russian olive and about 50% the sea buckthorn. Both farmers and non-farmers were knowledgeable of the apple, black pines, hawthorn and poplar trees (*Table 2*). Of the nitrogen fixing trees, the farmers had more knowledge of sea buckthorn compared to the non-farmers.

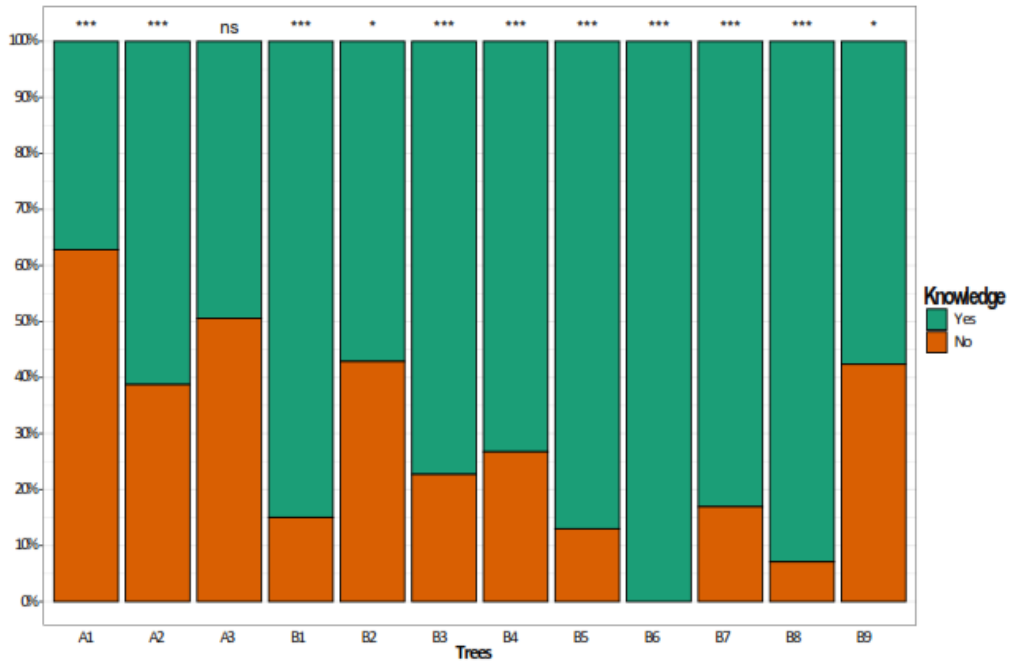

Figure 2. *Knowledge of trees in a semiarid zone. The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir, B9. ns, not significant; * $p \leq 0.05$; ** $p \leq 0.01$; and *** $p \leq 0.001$. Most participants had greater knowledge of the non-nitrogen fixing trees than the nitrogen fixing trees*

In descending order, fruit trees such as apple (B6), poplar (B8), hawthorn (B5), black pine (B1), oak (B7) were identified as of high importance (*Figure 3*) while other trees (nitrogen and non-nitrogen fixing) were either considered as having average or low importance. The nitrogen fixing trees (alder, Russian olive, and sea buckthorn) were not

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

considered of high priority neither on the farm nor in the wider environment (*Table 2*). With over 80% agreement, fruit trees had the highest priority of importance both for farm and environment among respondents while other trees, except chinaberry (B4), were prioritized for the environment.

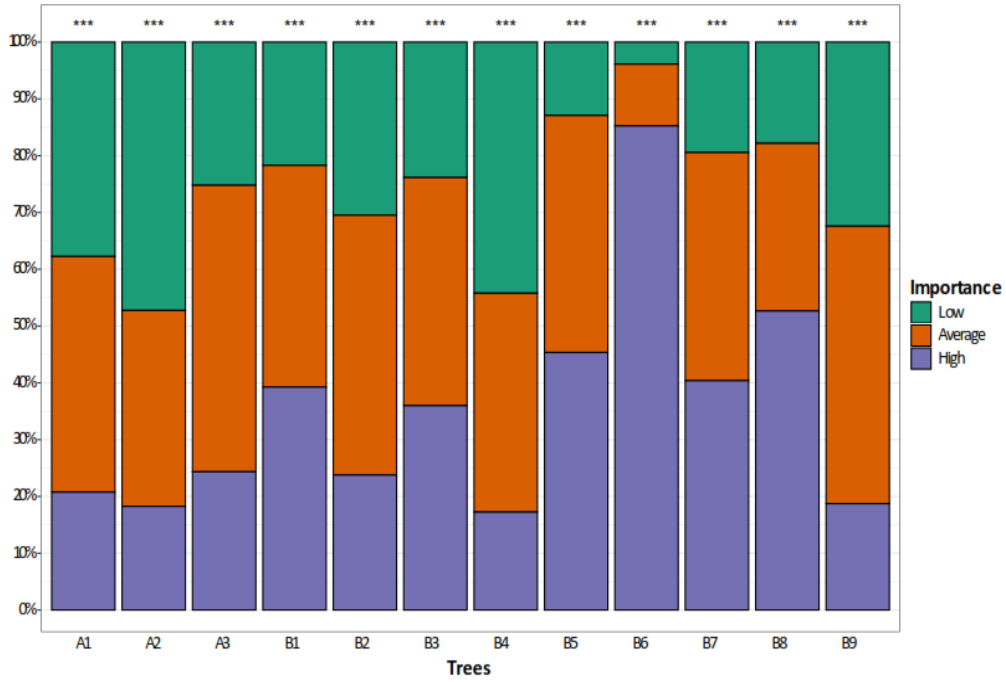

Figure 3. *Perception of trees importance in a semiarid zone. The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir, B9. *** $p \leq 0.001$. The perception of importance was highest for the fruit trees*

Table 2. *Knowledge and importance of trees among farmers and non-farmers in a semiarid zone (%)*

	Nitrogen-fixing trees (%)			Non-nitrogen-fixing trees (%)										
	A1	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**Total**	**p value**
Knowledge														
Farmers	15	55	58	86	53	79	83	86	100	84	91	49	73	< 0.001
Non-farmers	42	62	48	85	58	77	72	87	100	83	93	59	70	< 0.001
Importance														
Farm	15	15	23	32	21	31	18	38	82	32	47	15	32	< 0.001
Environment	23	18	25	46	26	41	17	52	88	47	57	22	40	< 0.001

The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir, B9. Significance was set at $p \leq 0.05$

Intercropping with fruit trees was preferred among the respondents (*Figure 4*). This did not differ between nitrogen to non-nitrogen fixing trees. Similarly, perception of

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

farmers and non-farmers favored the concept of intercropping these trees with fruits much more than legumes and cereals (*Table 3).*

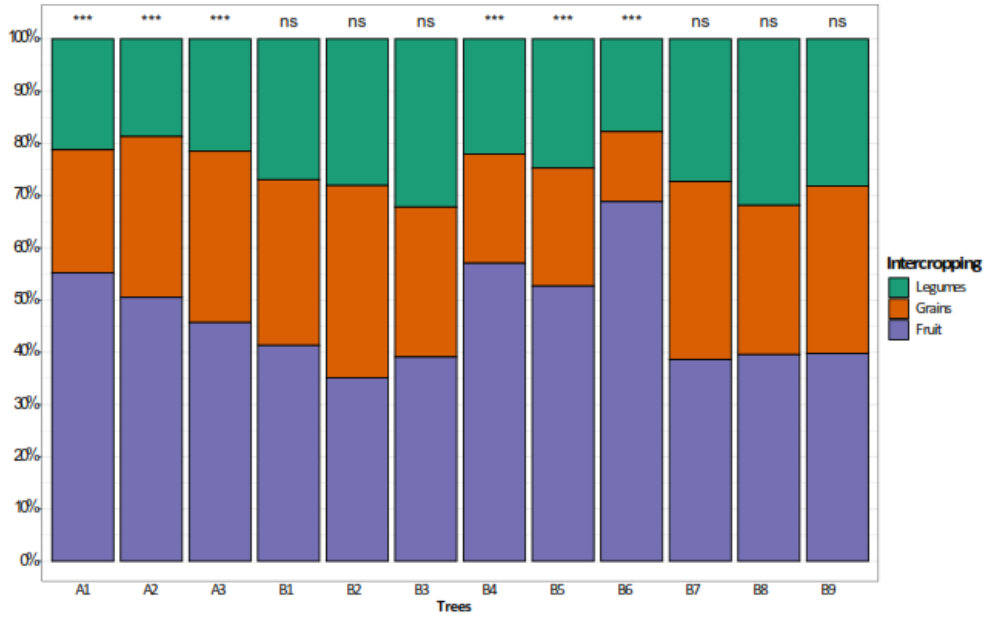

Figure 4. *Perception of tree-based intercropping in semiarid zone. The nitrogen fixing trees were alder, A1; Russian olive, A2; sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir-B9. ns, not significant; and *** $p \leq 0.001$. Most participants preferred intercropping fruit trees compared to other trees*

Table 3. *Intercropping and ecosystem services of trees among farmers and non-farmers in semiarid zone (%)*

			Nitrogen-fixing trees (%)			Non-nitrogen-fixing trees (%)										
			A1	**A2**	**A3**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**Total**	**p value**
Intercropping	Farmers	L	24	27	32	32	31	39	21	30	15	30	37	33	29	
		C	18	30	22	25	23	22	24	20	9	22	19	17	21	< 0.001
		F	59	42	45	43	46	39	55	50	76	48	44	50	50	
	Non-farmers	L	20	16	18	26	27	29	22	23	18	26	31	27	23	
		C	24	31	34	34	31	31	20	24	15	37	31	35	29	< 0.001
		F	55	53	46	41	33	40	58	53	67	37	38	38	47	
Ecosystem services	Farmers	C	26	28	34	31	33	38	12	15	14	27	29	33	26	
		P	32	33	22	36	28	24	38	43	54	35	38	25	35	0.512
		R	21	26	27	17	19	16	26	24	16	17	19	25	21	
		S	21	13	17	17	21	22	24	17	16	21	14	17	18	
	Non-farmers	C	36	18	25	33	32	30	22	20	15	34	26	30	26	
		P	21	34	30	26	17	15	38	41	47	24	29	18	29	< 0.001
		R	20	24	21	22	23	27	23	19	19	19	24	24	22	
		S	23	24	24	19	28	28	17	20	19	23	22	28	23	

The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak-B7; poplar, B8; and Turkish fir, B9. The options for intercropping were legumes (L), cereals (C), and fruits (F) and ecosystem services were cultural and habitat (C), provisioning (P), regulating (R) and supporting (S). Significance was set at $p \leq 0.05$

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Ecosystem services and community value

Cultural ecosystem services which focus on environmental conservation and wildlife habitat as well as provisioning ecosystem services which include the availability of food, fuel and fodders from trees were the major preferences of the respondents in this study. The perceived ecosystem services provided by each tree significantly differed except for sea buckthorn (nitrogen fixing) and poplar (non-nitrogen fixing) as shown in *Figure 5*. However, among farmers the perceived tree-based ecosystem services of trees did not significantly differ (*Table 3*) whereas non-farmers focused more on cultural and provisioning ecosystem services.

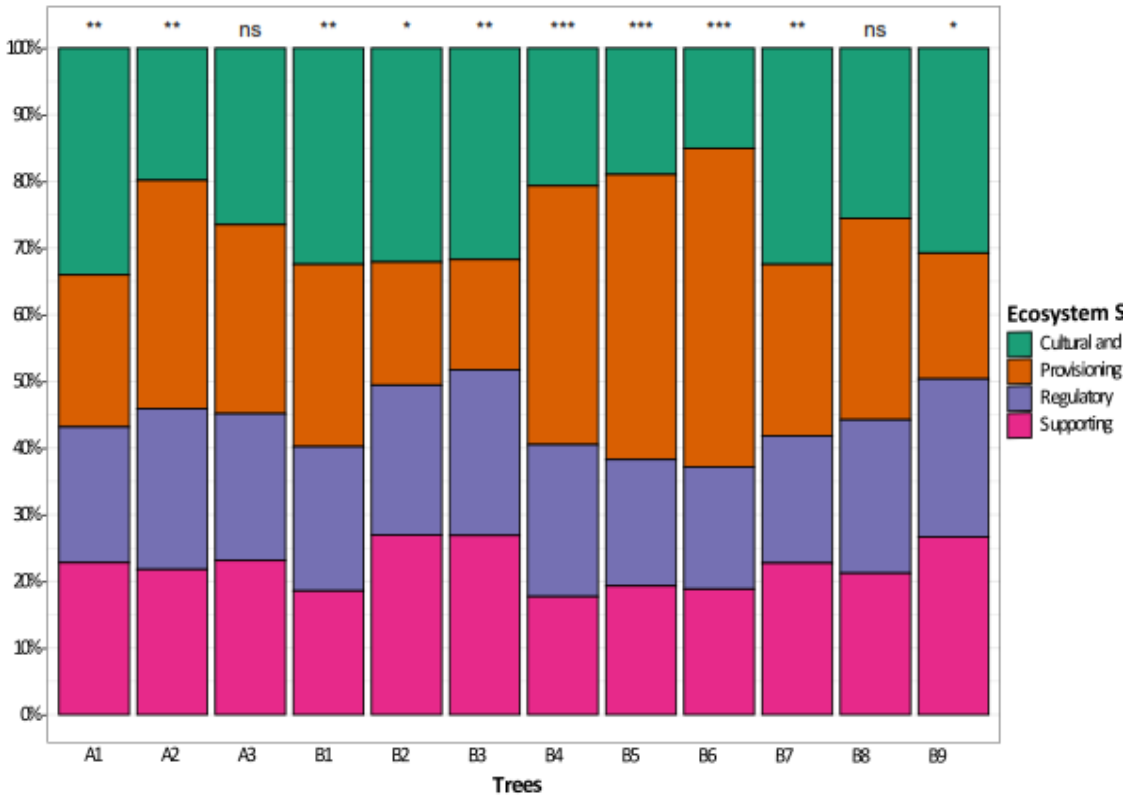

Figure 5. *Perception of tree-based ecosystem services in semiarid zone. The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir, B9. ns, not significant; * $p \leq 0.05$; ** $p \leq 0.01$; and *** $p \leq 0.001$. Ecosystem services varied with the type of tree*

Farmers and non-farmers had similar perception that environmental protection, health and income were key community values that influenced the choice of trees and their ecosystem services in Niğde Province. Aesthetics and wildlife habitat were also considered community values of the trees in this study whereas less consideration was given to culture, recreation, and religion. Black pine was particularly valued for environmental protection (*Figure 6*). Other trees valued for environmental protection include alder, black willow, weeping willow, oak and poplar. These trees, in addition to fruit trees, were valued for health, income, aesthetics and wildlife protection.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

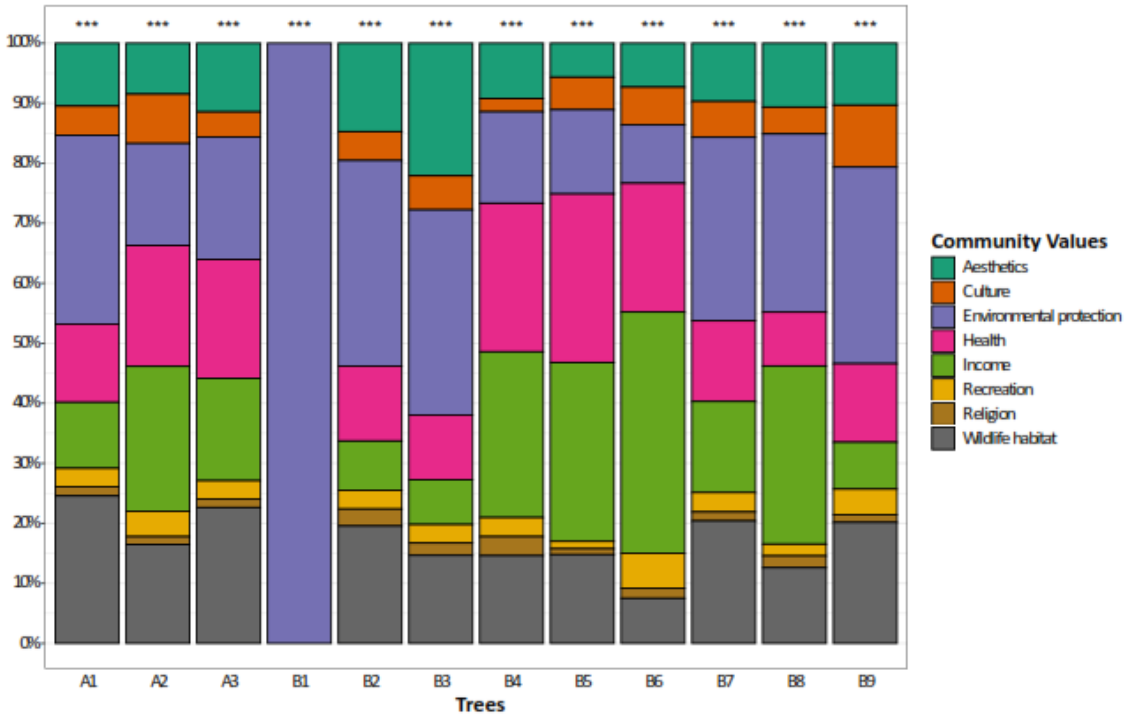

Figure 6. *Perception of tree-based community values in a semiarid zone. The nitrogen fixing trees were alder, A1; Russian olive, A2; and sea buckthorn, A3. The non-nitrogen fixing trees were black pine, B1; black willow, B2; weeping willow, B3; chinaberry, B4; hawthorn, B5; fruit trees such as apple, B6; oak, B7; poplar, B8; and Turkish fir, B9 *** $p \leq 0.001$. Environmental protection, health and income were the major community values driving the perceived ecosystem services of trees in the semiarid zone*

Tree planting

Both farmers and non-farmers agreed mostly that individuals should be involved with tree planting activities but opinions significantly differed on the perception that planting trees with known benefits should be the focus (*Table 4*). Nonetheless, there was a high perception of willingness to plant trees on the farms and in the general environment.

Table 4. *Tree planting among farmers and non-farmers in semiarid zone (%)*

	Tree planting indicators			
	A	**B**	**C**	**D**
Farmers	88	39	94	92
Non-farmers	93	23	88	82
Total	91	25	89	84
p value	0.171	0.016	0.758	0.395

The four indicators of tree planting were: A, everyone should be involved with planting; B, planting beneficial tree should be the focus; C, the willingness to plant beneficial trees in environment; and D, the willingness to plant beneficial trees on the farm

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Discussion

Knowledge and importance

The widespread knowledge of apple, hawthorn, black pine, oak and poplar trees among farmers and non-farmers in this study agreed with the assertions of Ertuğ (2000) and Çalışkan and Boydak (2017) that they are highly adapted non-actinorhizal (non-nitrogen fixing) plants in Central Anatolia, Türkiye. Apple production in Niğde Province accounts for major contribution to national-level apple production in Türkiye (Bozbuğa and Pırlak, 2012) while wild population of hawthorn popularly known as 'alıç' (Çalışkan et al., 2016) is common in Niğde Province. The respondents' knowledge of black pine agreed with the report of Ayan et al. (2021) that wild population of black pine are common in Central Anatolia. There is also a wide distribution of oak and poplar trees in Türkiye (Ugurlu et al., 2012; Eroğlu and Acar, 2018).

There was limited knowledge of nitrogen fixing trees such as Russian olive and sea buckthorn among respondents probably because there is decreasing value for horticultural use and food source (Riley et al., 2021). Kenar et al. (2020) reported the low organic matter and limited phosphorus in the slightly alkaline sandy-clay-loam soil supporting the steppe vegetation of Central Anatolia; the average soil nitrogen content is moderately sufficient and the knowledge of nitrogen fixing trees towards boosting agricultural productivity may not be priority even among the farmers.

The perception of high importance linked to apple, poplar, hawthorn, black pine and oak trees by the respondents likely came from the various local household to agroforestry uses in Central Anatolia and other parts of Türkiye. For instance, apple is an economically important plant in Türkiye with more than 600 local cultivars (Ercisli, 2004) used for fruit production and food additives both domestically and for export (Bayav and Karlı, 2021). Hawthorn seeds are widely dispersed in Türkiye by birds and humans as they feed on the small yellowish to red fleshy fruit containing high citric acid and fructose which makes it important for human nutrition (Gundogdu et al., 2014). It is also used in amenity plantings. Black pine and oak are particularly important indigenous agroforestry species in Central Anatolia (Çalışkan and Boydak, 2017) but are under stress imposed by pest, diseases, increased water deficiency as well as reduced genetic introgression (Riley, 2021).

Respondents' low to average perception of importance for the nitrogen fixing trees (alder, Russian olive and sea buckthorn) in this study both on the farm and in the wider environment reflected how the potential positive soil health contributions were either not known; known but not perceived as important for use; or the perceived importance of these trees were linked to limitation for use in Central Anatolia, Türkiye. The latter seemed the case as alder was reported as important for wood production with wide distribution in Northeastern Anatolia and Eastern Black Sea regions of Türkiye (Hızal and Erdin, 2016) but not particularly common in Central Anatolia. Yıldız et al. (2022) asserted that Russian olives were vital for afforestation to provide supporting ecosystem service in Central Anatolia even though about 60% of it may be lost over a 25-year period of establishment. Sea buckthorn is commonly found in central, eastern and northern Anatolia. This species has wide environmental tolerance, abundant fruit production and potential for soil improvement (Ilhan et al., 2021). However, water limitations of sea buckthorn propagation make it likely to grow better in northeastern Türkiye (Sezen et al., 2015) compared to Central Anatolia Türkiye.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Intercropping of trees in semiarid zone

The respondents' perception for intercropping was similar for nitrogen and non-nitrogen fixing trees supporting the opinion of Mitchell et al. (1991) that sustained production over a long period is the goal of intercropping not immediate nor merely the different soil health benefits of nitrogen and non-nitrogen fixing plants. In addition, the predominant perception among respondents to intercrop fruit trees primarily with other crops in an agricultural system supports the emerging concept of high value tree agroforestry (HVTAF) system. The intercropping of fruit trees such as apples, berries, olives with other crops is known as a high value tree agroforestry system that thrives on the mutual benefits of ecosystem services (Pantera et al., 2018; Kumar, 2020), improved land use, cost compensation on cultivation (Abourayya et al., 2022), improved agricultural productivity and increased farmers' profitability (Bakshi et al., 2019) through the tree-crop-soil interaction.

The priority on intercropping system studies in Türkiye have been on grains, legumes, or vegetables and their effect on soil nutrient, income level and agricultural productivity of intercropping such as in strawberry (*Fragaria x ananassa*) and radish (*Raphanus sativus*)/onion (*Allium cepa*)/lettuce (*Lactuca sativa*) (Karlidağ and Yildirim, 2009) as well as cereal and legumes for improved yield and forage quality (Yolcu et al., 2009). Given the water limitations in Central Anatolia, Kayan et al. (2018) reported the common practice of crop rotation such as wheat and chickpea for sustained production but there appeared to be no published studies on HVTAF in Central Anatolia, Türkiye.

Few available HVTAF studies in other semiarid zones of Türkiye were field experiments and not perception studies. These includes pistachio (*Pistacia vera*) intercropped with barley and vetch for improved yields in Şalıurfa, South-east Türkiye (Polat et al., 1999); pistachio intercropped with barley and vetch to improve mineral content of the pistachio in Gaziantep, Southeastern Anatolia (Surucu and Demirkiran, 2013); olive (*Olea europaea*) intercropped with barley, vetch and triticale (×*Triticosecale* sp) for improved soil health in Şalıurfa (Özturkmen et al., 2020); lettuce/radish intercropped with almond (*Prunus dulcis*), apple, apricot (*Prunus armeniaca*), cherry (*Prunus avium*) and pear (*Pyrus communis*) to determine the efficiency of land use and profitability (Karlidağ et al., 2022) in Malatya, Eastern Anatolia, Türkiye.

Other HVTAF studies had been conducted in China and even though they are field experimental studies, they provide further insight into the gains and challenges of tree-based intercropping and may be useful stimulant for increased community perceptions studies in semiarid agroecological zones. In a comparative study of apple intercropped with ryegrass (*Lolium perenne*) in arid area of northwest China, Zhang et al. (2022) reported reduced soil salinity and higher soil moisture. Similarly, Cheng et al. (2022) studied the economic and ecosystem service benefits of intercropped mango (*Mangifera indica*) with macadamia (*Macadamia integrifolia*) in a desertification control area in southwest China with the results indicating improved profits and reduced emergy inputs in the mango-macadamia fields compared to the maize (*Zea mays*) fields. There is a concern that not all fruit trees may be suitable for intercropping in the high value tree agroforestry system. Qiao et al. (2019) observed that intercropping apricot and walnut (*Juglans regia*) negatively affected wheat yield and quality compared to jujube (*Ziziphus jujube*) in the northwest China region. Also, a HVTAF system may impose

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

fruit tree-crop resource competition (Gao et al., 2013) besides the inherent risk of increased or altered pest populations (Li et al., 2018).

Ecosystem services and community value of trees in semiarid zone

The perception of most respondents that trees provide cultural and provisioning ecosystem services reflected how environmental conservation, wildlife habitat, availability of food, fuel and fodders from trees were the major ecosystem service preferences. Since the systematic review of Başak et al. (2022) on ecosystem services studies in Türkiye had shown the limited information on perceptions of tree-based ecosystem services in Türkiye, this study presents preliminary evidence for further perception studies in Central Anatolia, Türkiye. In recent perception studies conducted in Zagreb, Croatia (Kicic et al., 2022) and in New South Wales, Australia (Drew-Smythe et al., 2023), cultural and provisioning ecosystem services ranked high for communities given the benefits of aesthetics, recreation, habitat for wildlife, food and fodder.

Depending on either the social or functional value of a tree (Dorji et al., 2019), ecosystem services of trees may differ between environmental contexts (Shah et al., 2022). In arid zones such as Loess Plateau, China and Kashmir, India that are similar to Central Anatolia, apple trees have provisioning ecosystem services (Gao et al., 2013; Bhat et al., 2018). Black pine in Afyonkarahisar (Arı et al., 2014) and oak in the eastern Himalayas (Dorji et al., 2019) being less arid zones were also linked to cultural ecosystem services. Alder was reported to provide supporting services in the forest-watersheds of the eastern Himalayas (Sharma et al., 2008), Alaskan temperate rain forests (Deal et al., 2017) and central Peru (Visscher et al., 2020). Meanwhile, invasiveness of Russian olive in riparian ecosystems of North America have made it less likely to be studied for its supporting ecosystem services despite potential soil health benefits as an actinorhizal tree (Collette and Pither, 2015a,b; Nagler et al., 2011; Reynolds and Cooper, 2010).

Perception for community value such as environmental protection, health and income were major drivers for the perceived ecosystem services of trees among respondents. This supports the opinion of Shah et al. (2022) that a single tree may be valued for multiple reasons. For example, black pine is commonly used for afforestation purposes in semiarid zones of Türkiye and valued for aesthetics (Çalişkan and Boydak, 2017). Ari et al. (2014) reported the use of black pine for health support as traditional medicines in western Türkiye and its hardwood is highly priced for its quality (Gülsoy and Çinar 2019). Similarly, given the high income-earning potential of poplar, it provides an important capital resource for farmers in northwestern India (Sirohi et al., 2022). As expected, the economic value placed on apple in Niğde is no different from on the Loess Plateau, China, both semiarid zones (Gao et al., 2013) having intrinsic factor as fruit tree for human consumption. Meanwhile, community value of other trees in the semiarid zone may be influenced by extrinsic factors to the trees such as individual disposition to the tree, cultural and spiritual connection which may differ from one agroclimatic zone to another (Dorji et al., 2019).

Tree planting in semiarid zone

The agreement of farmers and non-farmers in this study for individuals to be involved with tree planting activities affirms the national efforts to prevent desertification and increase tree planting in Türkiye, given its vast semiarid areas

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

(Çalışkan and Boydak, 2017; Riley, 2021). Also, there was a high perception of willingness to plant trees on the farms and in the general environment by farmers and non-farmers. However, the survival rate of trees planted in semiarid and arid environments remains a major limiting factor (Jo and Park, 2017). Aridity coupled with anthropogenic activities (such as traditional grazing practices) have been suggested as major contributors to low long-term survival rates of trees and opined the use of adaptable exotic species in place of the rapidly declining native tree species (Çalışkan and Boydak, 2017; Riley, 2021). Jo and Park (2017) suggested that pit planting technique may enhance tree survival rate. Mauki and Kilonzo (2022) further showed that increased pit size with mulching and social commitment of communities to the protection of the trees enhanced survival in arid and semiarid areas of Tanzania. The perception for agroforestry was generally low among respondents, being the goal of planting beneficial trees. Farmers are major actors in driving agroforestry systems but in the study of perceptions among farmers on agroforestry in Tanzania, Hillburg (2014) identified limiting factors behind their perceptions. This includes poor knowledge of beneficial trees, inability to adequately predict outcomes of tree planting as well as inability to determine the risks involved. Fleming et al. (2019) also asserted that failed outcomes of previous agroforestry efforts, perception of high market uncertainties and associated high risks in addition to limited access to funds as factors that underlay the perception of farmers for agroforestry.

Conclusions

Knowledge and perception of importance of trees in Niğde Province, as representative of Central Anatolia, is driven by both functional and social valuation. Trees are important in this agroecological zone for afforestation, landscaping, ethnobotanical uses as well as wood and fruit production linked to economic purposes. Despite the high perception for agroforestry-based systems among farmers and non-farmers in the present study, empirical to social research remains limited for high value tree agroforestry in Türkiye and in particular tree-based ecosystem services in Central Anatolia. From this case study in Niğde Province, the ecosystem services of trees in semiarid agroecological zone did not appear to necessarily differ from other contexts, although, individual to community perceptions differed for particular tree species. In addition, intrinsic factors such as fruiting and wood quality may have influenced the social value given by the study participants, and similarly for extrinsic factors such as culture and spiritual connection. Nevertheless, there is a willingness at community level for tree planting, but this does not necessarily address the most important issues of tree establishment which is growth and long-term survival in semiarid agroecological zone. This finding presents a novel opportunity for researchers to further examine the perception of ecosystem services of other tree species among communities in other agroecological, high value tree agroforestry in Türkiye and higher social engagement to missing elements of theoretical and empirical studies of trees in agroecosystems.

Acknowledgements. This study was a part of the PhD research of EAO under scholarship provided by the Ayhan Sahenk Foundation. The support provided by Prof. Çiğdem Ulubaş Serçe is gratefully acknowledged. Abdulhamid Garba and Nida Ünlu assisted with Turkish translation of survey instrument; distribution of survey instrument and data entry was possible with help from my colleagues, Baqer Hussein Abass Al Abass, Olusola Adekoya, Theresa Adekoya, Hümerya Yıldız Akkamış, Mustafa Akkamış, Olivet

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

Delasi Gleku, Haruna Gaji Kolo, Sinem Tulukoğlu Kunt, Oluwatosin Dorcas Ogunkalu, Sunday Tope Olorunsogbon, Oyinkansola Olowu, Ayse Hayriye Saygı as well as Şefika Karlı and staff of Çamardı district agriculture and forestry directorate.

REFERENCES

[1] Abourayya, M. S., Kaseem, N. E., Mahmoud, T. S. M., Marzouk, N. M., Rakha, A. M. (2022): Intercropping young almond trees with snap bean under Nubaria region conditions. – Bulletin of the National Research Centre 46(1): 77. https://doi.org/10.1186/s42269-022-00766-4.

[2] Arı, S., Kargıoğlu, M., Temel, M., Konuk, K. (2014): Traditional tar production from the Anatolian black pine [*Pinus nigra* Arn. subsp. pallasiana (Lamb.) Holmboe var. pallasiana] and its usages in Afyonkarahisar, Central Western Turkey. – Journal of Ethnobiology and Ethnomedicine 10(29). https://doi.org/10.1186/1746-4269-10-29.

[3] Asbjornsen, H., Hernandez-Santana, V., Liebman, M., Bayala, J., Chen, J., Helmers, M., Ong, C. K., Schulte, L. A. (2014): Targeting perennial vegetation in agricultural landscapes for enhancing ecosystem services. – Renewable Agriculture and Food Systems 29(2): 101-125. https://doi.org/10.1017/S1742170512000385.

[4] Ayan, S., Yücedag, C., Simovski, B. (2021): A major tool for afforestation of semi-arid and anthropogenic steppe areas in Turkey: Pinus nigra J.F. Arnold subsp. pallasiana (Lamb.) Holmboe. – Journal of Forest Science 67(10): 449–463. https://doi.org/10.17221/74/2021-JFS

[5] Aydın, Y. (2022): Quantification of water requirement of some major crops under semi-arid climate in Turkey. – PeerJ 10: e13696. https://doi.org/10.7717/peerj.13696.

[6] Bakshi, P., Bali, K., Kour, K., Bhushan, A. (2019): Intercropping in fruit orchards: a way forward for doubling the farmer's income. – International Journal of Agriculture Sciences 11: 9274-9276.

[7] Başak, E., Cetin, N. I., Vatandaşlar, C., Pamukcu-Albers, P., Karabulut, A. A., Çağlayan, S. D., Besen, T., Erpul, G., Balkız, Ö., Çokçalışkan, B. A., Per, E., Atkin, G. (2022): Ecosystem services studies in Turkey: A national-scale review. – Science of The Total Environment 844: 157068. https://doi.org/10.1016/j.scitotenv.2022.157068.

[8] Bayav, A., Karlı, B. (2021): Economic Performance of Apple Farms: A Case of Isparta and Karaman Provinces of Turkey. – Turkish Journal of Agriculture - Food Science and Technology 9(4): 837-842. https://doi.org/10.24925/turjaf.v9i4.837-842.4290.

[9] Bhat, R., Hussain, S., Akhter, M., Sharma, M. K., Nazir, N., Khalil, A., A. Bangroo, S., Malik, A. R. (2018): Effect of intercrops on apple production cv. red delicious. – International Journal of Current Microbiology and Applied Sciences 7(06): 1543–1550. https://doi.org/10.20546/ijcmas.2018.706.184

[10] Blanco, J., Sourdril, A., Deconchat, M., Barnaud, C., San Cristobal, M., Andrieu, E. (2020): How farmers feel about trees: Perceptions of ecosystem services and disservices associated with rural forests in southwestern France. – Ecosystem Services 42: 101066. https://doi.org/10.1016/j.ecoser.2020.101066

[11] Bozbuğa, F., Pırlak, L. (2012): Determination of phenological and pomological characteristics of some apple cultivars in Niğde-Turkey ecological conditions. – Journal of Animal and Plant Science 22(1): 183-187.

[12] Çaliskan, O., Bayazit, S., Gunduz, K. (2016): Hawthorn species from turkey and potential usage for horticulture. – VII International Scientific Agriculture Symposium (Agrosym), https://doi.org/10.7251/AGRENG1607045

[13] Çalışkan, S., Boydak, M. (2017): Afforestation of arid and semiarid ecosystems in Turkey. – Turkish Journal of Agriculture and Forestry 41: 317-330. https://doi.org/10.3906/tar-1702-39.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

[14] Cayci, G., Heng, L. K., Öztürk, H. S., Sürek, D., Kütük, C., Sağlam, M. (2009): Crop yield and water use efficiency in semi-arid region of Turkey. – Soil and Tillage Research 103(1): 65-72. https://doi.org/10.1016/j.still.2008.09.004.
[15] Cheng, H., Hu, W., Zhou, X., Dong, R., Liu, G., Li, Q., Zhang, X. (2022): Fruit tree legume herb intercropping orchard system is an effective method to promote the sustainability of systems in a karst rocky desertification control area. – Forests 13(10): 1536. https://doi.org/10.3390/f13101536.
[16] Collette, L. K. D., Pither, J. (2015a): Modeling the potential North American distribution of Russian olive, an invader of riparian ecosystems. – Plant Ecology 216(10): 1371-1383. https://doi.org/10.1007/s11258-015-0514-4.
[17] Collette, L. K. D., Pither, J. (2015b): Russian-olive (*Elaeagnus angustifolia*) Biology and ecology and its potential to invade northern North American Riparian Ecosystems. – Invasive Plant Science and Management 8(1): 1-14. https://doi.org/10.1614/IPSM-D-14-00037.1.
[18] Cyamweshi, R. A., Kuyah, S., Mukuralinda, A., Ngango, J., Mbaraka, S. R., Manirere, J. D., Muthuri, W. C. (2023): Farming with trees for soil fertility, moisture retention and crop productivity improvement: Perceptions from farmers in Rwanda. – Small-Scale Forestry 22(4): 649–667. https://doi.org/10.1007/s11842-023-09547-x
[19] Deal, R., Orlikowska, E., D'Amore, D., Hennon, P. (2017): Red alder-conifer stands in Alaska: an example of mixed species management to enhance structural and biological complexity. – Forests 8(4): 131. https://doi.org/10.3390/f8040131.
[20] Drew-Smythe, J. J., Davila, Y. C., McLean, C. M., Hingee, M. C., Murray, M. L., Webb, J. K., Krix, D. W., Murray, B. R. (2023): Community perceptions of ecosystem services and disservices linked to urban tree plantings. – Urban Forestry and Urban Greening 82: 127870. https://doi.org/10.1016/j.ufug.2023.127870
[21] Dorji, T., Brookes, J., Facelli, J., Sears, R., Norbu, T., Dorji, K., Chhetri, Y., Baral, H. (2019): Socio-cultural values of ecosystem services from oak forests in the Eastern Himalaya. – Sustainability 11(8): 2250. https://doi.org/10.3390/su11082250.
[22] Ercisli, S. (2004): A short review of the fruit germplasm resources of Turkey. – Genetic Resources and Crop Evolution 51(4): 419-435. https://doi.org/10.1023/B:GRES.0000023458.60138.79.
[23] Erinç, S., Tuncdilek, N. (1952): The agricultural regions of Turkey. – Geographical Review 42(2): 179. https://doi.org/10.2307/211384.
[24] Eroğlu, E., Acar, C. (2018): A visual assessment of roadside poplar plantings in turkey. Ankara University – Journal of Agricultural Science 24:185-198. https://doi.org/10.15832/ankutbd.446436
[25] Ertuğ, F. (2000): An ethnobotanical study in Central Anatolia (Turkey). – Economic Botany 54(2): 155-182. https://doi.org/10.1007/BF02907820.
[26] Fleming, A., O'Grady, A. P., Mendham, D., England, J., Mitchell, P., Moroni, M., Lyons, A. (2019): Understanding the values behind farmer perceptions of trees on farms to increase adoption of agroforestry in Australia. – Agronomy for Sustainable Development 39(1): 9. https://doi.org/10.1007/s13593-019-0555-5
[27] Gao, L., Xu, H., Bi, H., Xi, W., Bao, B., Wang, X., Bi, C., Chang, Y. (2013): Intercropping competition between apple trees and crops in agroforestry systems on the loess plateau of China. – PLoS ONE 8(7): e70739. https://doi.org/10.1371/journal.pone.0070739.
[28] Gerstenberg, T., Hofmann, M. (2016): Perception and preference of trees: A psychological contribution to tree species selection in urban areas. – Urban Forestry and Urban Greening 15: 103–111. https://doi.org/10.1016/j.ufug.2015.12.004
[29] Gülsoy, S., Çinar, T. (2019): The relationships between environmental factors and site index of Anatolian black pine (*Pinus nigra* Arn. subsp. pallasiana (Lamb.) Holmboe) stands in Demirci (Manisa) district, Turkey. – Applied Ecology and Environmental Research 17(1): 1235-1246. https://doi.org/10.15666/aeer/1701_12351246.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

[30] Gundogdu, M., Ozrenk, K., Ercisli, S., Kan, T., Kodad, O., Hegedus, A. (2014): Organic acids, sugars, vitamin C content and some pomological characteristics of eleven hawthorn species (Crataegus spp.) from Turkey. – Biological Research 47(1): 21. https://doi.org/10.1186/0717-6287-47-21.

[31] Haines-Young, R., Potschin, M. (2013): CICES, In: Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. – EEA Framework Contract No EEA/IEA/09/00.

[32] Hillbur, S. (2014): Farmer's perceptions of agroforestry – A case study about the obstacles and opportunities for agroforestry adoption in Babati, Tanzania. – Thesis-Södertörn University, School of Natural Sciences, Technology and Environmental studies.

[33] Hızal, K. T., Erdin, N. (2016): Radial variation of annual ring width and fiber dimensions from natural and plantation trees of alder (*Alnus glutinosa* L. Gaertner) Wood. – Ormancılık Dergisi 12 (2): 1-12.

[34] Ilhan, G., Gundogdu, M., Karlović, K., Židovec, V., Vokurka, A., Ercişli, S. (2021): Main agro-morphological and biochemical berry characteristics of wild-grown sea buckthorn (Hippophae rhamnoides L. ssp. Caucasica Rousi) genotypes in Turkey. – Sustainability 13(3): 1198. https://doi.org/10.3390/su13031198

[35] Jo, H.-K., Park, H.-M. (2017): Effects of pit plantings on tree growth in semi-arid environments. – Forest Science and Technology 13(2): 66-70. https://doi.org/10.1080/21580103.2017.1312559.

[36] Karlidag, H., Yildirim, E. (2009): Strawberry intercropping with vegetables for proper utilization of space and resources. – Journal of Sustainable Agriculture 33(1): 107-116. https://doi.org/10.1080/10440040802587462.

[37] Karlidağ, H., Kutsal, İ. K., Karaat, F., Küçük, R., Kan, T. (2022): Evaluation of an intercropping system: lettuce and radish growing in fruit sapling production. – Black Sea Journal of Agriculture 5(3): 220-226. https://doi.org/10.47115/bsagriculture.1056280.

[38] Kart, M. Ç. Ö., Abay, C. F., Güngör, S., Özer, Z. (2017): Seed Supply and seed preferences of potato farmers: Niğde Central and Izmir Odemis Provinces. – Management, Economic Engineering in Agriculture and Rural Development 17(2): 239-250.

[39] Kayan, N., Kutlu, İ., Ayter, N. G. (2018). Effects of Different Tillage and Soil Residual Nitrogen on Chickpea Yield under Wheat-Chickpea Rotation System in Central Anatolia Condition. Yuzuncu Yil University – Journal of Agricultural Science 28:91-95.

[40] Kenar, N., Şekerciler, F., Çoban, S. (2020): The phytosociology, ecology, and plant diversity of new plant communities in Central Anatolia (Turkey). – Hacquetia 19(1): 1-22. https://doi.org/10.2478/hacq-2019-0014.

[41] Kičić, M., Haase, D., Marin, A. M., Vuletić, D., Ostoić, S. K. (2022): Perceptions of cultural ecosystem services of tree-based green infrastructure: A focus group participatory mapping in Zagreb, Croatia. – Urban Forestry and Urban Greening 78: 127767.

[42] Krishnamurthy, L., Krishnamurthy, P. K., Rajagopal, I., Peralta Solares, A. (2019): Can agroforestry systems thrive in the drylands? Characteristics of successful agroforestry systems in the arid and semi-arid regions of Latin America. – Agroforestry Systems 93(2): 503–513. https://doi.org/10.1007/s10457-017-0143-0

[43] Kumar, P. N. (2020): Effect of Intercropping on fruit crops: a review. – International Journal of Current Microbiology and Applied Sciences 9(12): 745-755. https://doi.org/10.20546/ijcmas.2020.912.090.

[44] Li, H., Pan, H., Wang, D., Liu, B., Liu, J., Zhang, J., Lu, Y. (2018): Intercropping with fruit trees increases population abundance and alters species composition of spider mites on cotton. – Environmental Entomology 47(4): 781-787. https://doi.org/10.1093/ee/nvy063.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

[45] Mauki, D., Kilonzo, M. (2022): Planting pit size determines successful tree seedling establishment in arid and semi-arid region of Tanzania. – Environmental and Sustainability Indicators 15: 100197. https://doi.org/10.1016/j.indic.2022.100197.
[46] Mitchell, C. C., Westerman, R. L., Brown, J. R., Peck, T. R. (1991): Overview of long-term agronomic research. – Agronomy Journal 83: 24-29.
[47] Müderrisoğlu, H., Eroğlu, E., Özkan, Ş., Ak, K. (2006): Visual perception of tree forms. – Building and Environment 41(6): 796–806. https://doi.org/10.1016/j.buildenv.2005.03.008
[48] Nagler, P. L., Glenn, E. P., Jarnevich, C. S., Shafroth, P. B. (2011): Distribution and abundance of salt cedar and Russian olive in the western United States. – Critical Reviews in Plant Sciences 30(6): 508–523. https://doi.org/10.1080/07352689.2011.615689
[49] Ozturkmen, A. R., Ramazanoglu, E., Almaca, A., Çakmakli, M. (2020): Effect of intercropping on soil physical and chemical properties in an olive orchard. – Applied Ecology and Environmental Research 18(6): 7783–7793. https://doi.org/10.15666/aeer/1806_77837793
[50] Pantera, A., Burgess, P. J., Mosquera Losada, R., Moreno, G., López-Díaz, M. L., Corroyer, N., McAdam, J., Rosati, A., Papadopoulos, A. M., Graves, A., Rigueiro Rodríguez, A., Ferreiro-Domínguez, N., Fernández Lorenzo, J. L., González-Hernández, M. P., Papanastasis, V. P., Mantzanas, K., Van Lerberghe, P., Malignier, N. (2018): Agroforestry for high value tree systems in Europe. – Agroforestry Systems 92(4): 945-959. https://doi.org/10.1007/s10457-017-0181-7.
[51] Polat, T., Acar, İ., Baysal, İ., Şılbır, Y., Ak, B. E. (1999): Investigations on the Effect of Vetch (Vicia sativa L.) + Barley (Hordeum vulgares L.) mixture ratios that can be grown as sub plants in ceylanpinar rainfed conditions on pistachio (Pistacio vera L.) plantations. – Proceedings of GAP I. agricultural congress, Şanlıurfa, 821-828.
[52] Qiao, X., Sai, L., Chen, X., Xue, L., Lei, J. (2019): Impact of fruit-tree shade intensity on the growth, yield, and quality of intercropped wheat. – PLoS ONE14(4): e0203238. https://doi.org/10.1371/journal.pone.0203238.
[53] Reynolds, L. V., Cooper, D. J. (2010): Environmental tolerance of an invasive riparian tree and its potential for continued spread in the southwestern US. – Journal of Vegetation Science 21(4): 733-743. https://doi.org/10.1111/j.1654-1103.2010.01179.x.
[54] Riley, I. T. (2021): A case for assessing Allocasuarina and Casuarina spp. for use in agroecosystem improvement in semi-arid areas with a focus on Central Anatolia, Turkey. – Frontiers of Agricultural Science and Engineering 8(4): 568. https://doi.org/10.15302/J-FASE-2019270.
[55] Riley, I. T., Olowu, E., Jawneh, K., Atli, M. (2021): Actinorhizal plants of Turkey: formation of nodules, cluster roots and ectomycorrhizal roots. – Mediterranean Agricultural Sciences 34(3): 307-313. https://doi.org/10.29136/mediterranean.972937.
[56] Ruppert, D., Welp, M., Spies, M., Thevs, N. (2020): Farmers' perceptions of tree shelterbelts on agricultural land in rural Kyrgyzstan. – Sustainability 12(3): 1093. https://doi.org/10.3390/su12031093
[57] Segnon, A., Achigan-Dako, E., Gaoue, O., Ahanchédé, A. (2015): Farmer's knowledge and perception of diversified farming systems in sub-humid and semi-arid areas in Benin. – Sustainability 7(6): 6573–6592. https://doi.org/10.3390/su7066573
[58] Sezen, I., Ercisli, S., Cakir, O., Koc, A., Temim, E., Hadziabulic, A. (2015): Biodiversity and landscape use of sea buckthorn (Hippophae rhamnoides L.) in the Coruh valley of Turkey. – International Journal of Agriculture and Wildlife Science 57(1): 23–28. https://doi.org/10.1007/s10341-014-0227-1
[59] Shah, A. M., Liu, G., Huo, Z., Yang, Q., Zhang, W., Meng, F., Yao, L., Ulgiati, S. (2022): Assessing environmental services and disservices of urban street trees. An application of the emergy accounting. – Resources, Conservation and Recycling 186: 106563. https://doi.org/10.1016/j.resconrec.2022.106563.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738

[60] Sharma, E., Sharma, R., Sharma, G., Rai, S. C., Sharma, P., Chettri, N. (2008): Values and services of nitrogen-fixing alder-based cardamom agroforestry systems in the eastern Himalayas. – In: Snelder, D. J., Lasco, R. D. (eds.) Smallholder tree growing for rural development and environmental services. Springer Netherlands. pp. 393-409. https://doi.org/10.1007/978-1-4020-8261-0_18.

[61] Sirohi, C., Bangarwa, K. S., Dhillon, R. S., Chavan, S. B., Handa, A. K. (2022): Productivity of wheat (*Triticum aestivum* L.) and soil fertility with poplar (*Populus deltoides*) agroforestry system in the semi-arid ecosystem of Haryana, India. – Current Science 122(9): 1072. https://doi.org/10.18520/cs/v122/i9/1072-1080.

[62] Surucu, A., Demirkiran, A. R. (2013): Effects of intercropping on mineral content of pistachio in southeast of Turkey. – Journal of Food, Agriculture & Environment 11 (3&4): 883-886.

[63] TCKTB (2023): Republic of Türkiye Ministry of Culture and Tourism, Central Anatolia. – Available from https://www.ktb.gov.tr/EN-99767/central-anatolia.html.

[64] TCVNMM (2022): Annual climate data of Niğde Province, Central Anatolia, Turkey. – TC Niğde Valiliği, Metroloji Müdürlüğü.

[65] Teixeira, F. Z., Bachi, L., Blanco, J., Zimmermann, I., Welle, I., Carvalho-Ribeiro, S. M. (2019): Perceived ecosystem services (ES) and ecosystem disservices (EDS) from trees: Insights from three case studies in Brazil and France. – Landscape Ecology 34(7): 1583–1600. https://doi.org/10.1007/s10980-019-00778-y

[66] The jamovi project (2021): jamovi, Version 2.0.0. – Computer Software, Available from https://www.jamovi.org.

[67] TÜİK (2020): Turkish Statistical Institute, Ankara, Turkey. – Available from https://www.tuik.gov.tr/Home/Index.

[68] Uğurlu, E., Roleček, J., Bergmeier, E. (2012): Oak woodland vegetation of Turkey—A first overview based on multivariate statistics. – Applied Vegetation Science 15(4): 590–608. https://doi.org/10.1111/j.1654-109X.2012.01192.x

[69] Visscher, A. M., Vanek, S., Meza, K., De Goede, R. G. M., Valverde, A. A., Ccanto, R., Olivera, E., Scurrah, M., Fonte, S. J. (2020): Eucalyptus and alder field margins differ in their impact on ecosystem services and biodiversity within cropping fields of the Peruvian Andes. – Agriculture, Ecosystems & Environment 303: 107107. https://doi.org/10.1016/j.agee.2020.107107.

[70] Wagner, S., Rigal, C., Liebig, T., Mremi, R., Hemp, A., Jone, M., Price, E., Preziosi, R. (2019): Ecosystem services and importance of common tree species in coffee-agroforestry systems: local knowledge of small-scale farmers at Mt. Kilimanjaro, Tanzania. – Forests, 10(11): 963; https://doi.org/10.3390/f10110963

[71] Wezel, A., Haigis, J. (2000): Farmers' perception of vegetation changes in semi-arid Niger. – Land Degradation and Development 11(6): 523–534. https://doi.org/10.1002/1099-145X(200011/12)

[72] Yıldız, O., Eşen, D., Sargıncı, M., Çetin, B., Toprak, B., Dönmez, A. H. (2022): Restoration success in afforestation sites established at different times in arid lands of Central Anatolia. – Forest Ecology and Management 503: 119808. https://doi.org/10.1016/j.foreco.2021.119808

[73] Yolcu, H., Polat, M., Aksakal, V. (2009): Morphologic, yield and quality parameters of some annual forages as sole crops and intercropping mixtures in dry conditions for livestock. – Journal of Food Agriculture and Environment 7(3-4):594-599.

[74] Zhang, S., Liu, T., Wei, W., Shen, L., Wang, X., Tuertia, T., Li, L., Zhang, W. (2022): In arid regions, forage mulching between fruit trees rows enhances fruit tree light and lowers soil salinity. – Agriculture 12(11): 1895. https://doi.org/10.3390/agriculture12111895

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_721738