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Adoption of agroforestry systems by smallholders' farmers in the Sudano-Sahelian zones of Mali and Burkina Faso, West Africa

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Abstract Despite the well-known potential of agroforestry systems to sustain livelihoods and ecosystem services, their targeted adoption in the Sudano-Sahelian zone of West Africa is low. To address this, we used questionnaires with 279 farmers to understand their socio-economic characteristics determining the adoption of agroforestry technologies and to record the preferred tree species in the Koulikoro region of Mali and West-Central region of Burkina Faso. The result of a binary logistic regression showed that income, off farm activities, average number of owned sheep, cooperative membership, forage security, and maintained trees and shrubs fostered the adoption of agroforestry technologies. Contrarily, the adoption of agroforestry technologies was negatively influenced by household size and crop yield. Our data show that agroforestry parklands are the most popular agroforestry technology. The most common agroforestry tree species in the study region was *Vitellaria paradoxa* C. F. Gaertn. The dominance of *V. paradoxa* within these parklands may be partly explained by the tree's adaptation to severe drought and fire hazards, which are common to the study region. The study also revealed that smallholder farmers in Mali maintained trees on farms mainly for food security, whereas in Burkina Faso trees were mainly kept for maintaining soil fertility. We conclude that in all initiatives aimed at promoting the adoption of agroforestry in the study region, efforts should be made to consider farmers' socioeconomic characteristics, tree preferences, and perceptions (as identified in this study).

Keywords Arid zone · Agroforestry · Climate smart agriculture · Decision making · Land use · Logistic regression

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Introduction

The West African Sahel comprises Burkina Faso, Mali, Mauritania, Niger and Senegal covering an area of about 3 million km^2 (UN 2023). The region has an average population growth rate of 2.9%, which at a current population of 93.5 million (UN 2023) is projected to increase to 540 million by 2100 (Garenne 2016; UNFPA 2020). Since the 1980´s, the Sahel has received a lot of international attention because of extended droughts which have exacerbated poverty and malnutrition (Adeyeye et al. 2023). It is estimated that 60% of the West African Sahelian population are malnourished (OCDE 2020) and 40% are living below the poverty line (AAH 2021). The majority of people, especially those in rural communities, directly or indirectly depend on tree components to sustain their livelihoods. Increasing population has accelerated the demands for forest products hence putting growing pressure on forest resources. As a result, the West African Sahel has the highest rate of deforestation and soil degradation worldwide (Sanogo et al. 2020; OECD 2022).

For decades agroforestry systems were introduced and promoted throughout the Sahelian region of West Africa to foster food security and environmental protection. Thereby agroforestry is referred to as a resilient land use system which comprises the integration of woody perennials with crops and/or livestock on the same land (Nair et al. 2021). Many agroforestry trees provide fruits especially after the cropping season, fuelwood, timber, and resin which serve as source of food and cash as these products are sold (Assogbadjo et al. 2012). For some species prunning of leaves and twigs offers nutritious fodder (Bazié et al. 2012; Zampaligré 2012). Nitrogen fixation by leguminous trees and annual litterfall supply nitrogen, phosphorus, and organic material to improve soil fertility (Kho et al. 2001). Also, incorporation of trees in agricultural landscapes may contribute to biodiversity conservation and carbon sequestration (Meragiaw 2017; Neya et al. 2020).

Despite the numerous documented benefits of agroforestry systems (Boffa 1999; Swallow et al. 2006; Binam et al. 2017; Bayala et al. 2018; Nair et al. 2022; Afework et al. 2023), and decades-long efforts to make them popular among farmers, their de novo adoption in the West African Sudano-Sahelian zones has been low (Sanou et al. 2019). Newly established agroforestry systems by themselves may have little impact on quickly improving farmer livelihoods and enhancing ecosystem services (Kiyani et al. 2017; Afework et al. 2023). Most studies focused on the biophysical and economical aspects of agroforestry systems and neglect social aspects (Binam et al. 2017; Sanogo et al. 2020). According to Tega and Bojago (2023) farmers' socioeconomic characteristics such as farm size, education, extension service, and soil erosion are important determinants for agroforestry adoption in Ethiopia. In Tanzania agroforestry adoption is determined by farmers' involvement in agroforestry projects, type of land, perception about rainfall, land and agroforestry rights, and readiness to invest in improving soil fertility (Jha et al. 2021). Evidently, agroforestry practices vary with geographic location reflecting differences in socio-economic conditions, farm management, and institutional characteristics influencing their adoption. To satisfy local needs and preferences it is important that promotion of agroforestry is based on adequate knowledge about household characteristics. Our study addresses existing knowledge gaps in the West African Sudano-Sahelian zone concerning farmers' attitudes to and preferences for agroforestry systems by (i) determining relevant socioeconomic characteristics and farm management practices, and (ii) identifying adopted agroforestry technologies and farmers' perception on maintained trees/shrubs species in croplands. Our conceptual framework addresses factors which directly influence whether farmers adopt agroforestry practices or not (Fig. 1).

Materials and methods

Study area

The study was conducted in the Koulikoro region (17.57° N, 4.00° W) of Mali and the West-Central region (12.24° N, 1.56° W) of Burkina Faso. Both regions are located in the Sudano-Sahelian zone of Mali and Burkina Faso. In Mali, the Sudano-Sahelian zone has a three decades annual average rainfall ranging from 550 to 800 mm and temperatures from 24 to 29 °C (World-Bank 2017; Dembélé et al. 2020). For Burkina Faso, the Sudano-Sahelian zone has a three decades average annual rainfall ranging from 600 to 900 mm, and temperatures from 25 to 30 °C (De Longueville et al. 2016; Balima et al. 2020). Both study locations are dominated by heavily leached tropical ferruginous soils (Hien 2004) with the vegetation subjected to annual bush fires (Caillault et al. 2010; Aboul-Hadi et al. 2023). Consequently, the vegetation is characterized by a continuous grass layer dotted with scattered, open canopy trees (Bayala et al. 2014). Within the study areas, agriculture is dominated by the cultivation of maize (*Zea mays*

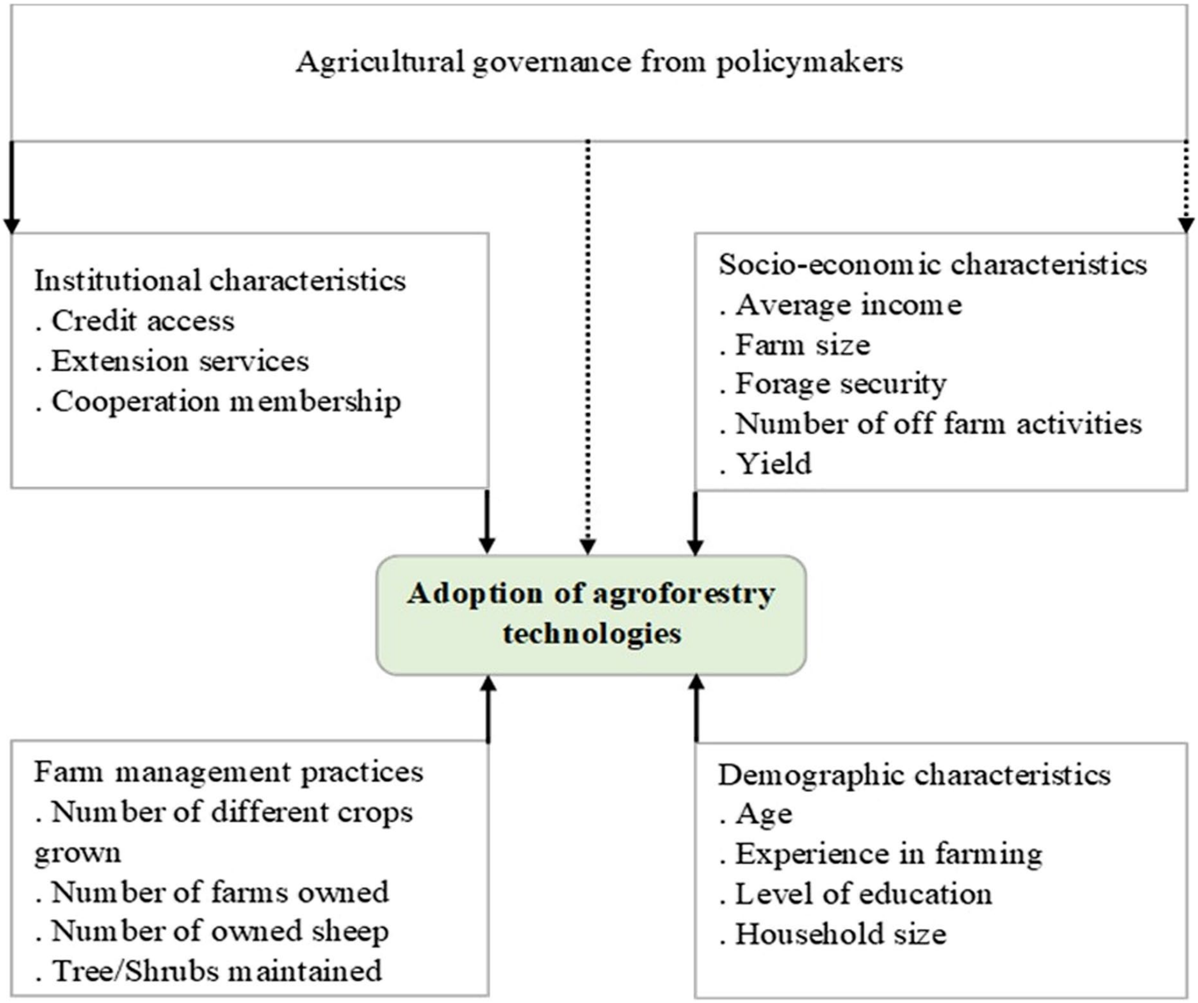

Fig. 1 Conceptual framework of agroforestry technologies adoption in the Sudano-Sahelian zones of Mali and Burkina Faso

L.), millet (*Pennisetum glaucum* L.R. Br.) and sorghum (*Sorghum bicolor* L.) under the aforementioned scattered trees in an open parkland systems regularly grazed by herds of small and large ruminants after croplands have been harvested (Kabore et al. 2015).

For this study, we purposely selected three typical Sudano-Sahelian villages in each country. For many years, all six villages have experienced the presence of agricultural research and developmental projects. In the Koulikoro Region of Mali, we selected the villages Mafèya, Féya and Tanabougou. In Burkina Faso's West Central region, we studied Saria, Tempèlga, and Ramonkodogo. Among the 764 households within the study area, the number of household heads interviewed for each village was determined by applying the 10% population rate proposed by Yamane (1967): $n = \frac{N}{1+N(e)^2}$, where n is the sample size, N is the population size, and e is the precision level. Subsequently, 279 household heads from both study locations (103 for Mali and 176 for Burkina Faso) were randomly selected for interviews.

Interviews

Closed and open-ended questions were used to record farmers' socioeconomic characteristics, farm management practices and perceptions about agroforestry trees. Questionnaires were pre-tested through focus groups discussions with farmers, extension officers, local government officers and NGOs. The 279 farmers used for the study were selected randomly from a farmer list obtained from agriculture extension officers at each study location. The primary data obtained through the questionnaire were complemented by secondary data obtained from extension officers, NGOs, members of research institutions and local government officials. Extension officers supplied farmer lists, farm sizes and production systems whereas information on innovative agricultural technology introduced in the study area was provided by the local agriculture extension office of Koulikoro for Mali and the Saria station of the Institute of the Environment and Agricultural Research (INERA) for Burkina Faso.

Data analysis

Student t-tests were used to determine the socioeconomic and farm characteristic differences between farmers in Mali and Burkina Faso. Descriptive statistics were employed to show farmers' perceptions about trees and applied agroforestry technologies. Binary logistic regression was used to understand farmers' decision to either adopt or reject agroforestry technologies based on their socioeconomic and farm characteristics (Table 1). A farmer can only adopt or reject an agroforestry technology, which was modelled as:

$$P(y) = \text{expo}\ (\beta_0 + \beta_x)/(1 + \text{expo}\ (\beta_0 + \beta_x)),$$

where y is the vector of binary response variables for a household that takes the values 1 for yes and 0 for no, and X is the matrix that contains the socio-economic characteristics of the household, and the farm characteristics. β_0 and β_1 are coefficients estimated based on the data: P(y) = probability of the event y coded with 1 when happening and otherwise 0. The logit was modelled as:

$$\text{logit}\left(\frac{P(yi = 1|Xi)}{1 - P(yi = 1|Xi)}\right) = \beta_0 + \beta_{1xi1} + \beta_{1xi2} + \cdots + \beta_{1xi16+\epsilon i},$$

where $1 - P(y_i = 1|X_i)$ is the probability of adopting agroforestry technologies, and ϵi is the error term of the binomial logit model. Data analyzed in binary logistic regression models were tested for multicollinearity which led to the removal of farmers' age and experience since they had a variation inflation factor > 4. After the elimination of these two variables, the Akaike information criterion declined from 329 to 319 suggesting a better model fit.

Table 1 Variables of the model used in the logit model for agroforestry technologies adoption in the Sudano-Sahelian zones of Mali and Burkina Faso

Independent variables	Categorical units
Level of education	Years
Farm size	ha
Fertilizer application	kg ha^{-1}
Household size	Individuals
Average income	US$/year
Number of different crops grown by farmer	Species
Number of farms owned by farmer	Number
Number of off farm activities applied by farmer	Activity
Number of sheep owned by farmer	Heads
Number of trees/shrubs in farm	Species
Yield	kg ha^{-1}
Cooperative membership	Yes = 1 and no = 0
Access to credit	Yes = 1 and no = 0
Access to extension service	Yes = 1 and no = 0
Forage security	Yes = 1 and no = 0
Agroforestry technology adoption	Yes = 1 and no = 0

Numbers presented are means and respective standard errors of the mean in parenthesis. The conversion rate for average income was 619 XOF to 1 US$

Results

Profile of the respondents

The average age of farmers in the two study locations was 58 years, whereby in the West-Central region the average farmer's age was 9% higher ($p < 0.01$) than in Koulikoro (Table 2). Similarly, the number of different crops grown, years of experience in farming and level of education in the West-Central region were 25%, 27%, and 33% respectively, higher ($p < 0.01$) than in Koulikoro. Contrarily farm size, household size, and average income in Koulikoro, were 84%, 10%, and 16% respectively, higher ($p < 0.01$) than in West-Central Burkina Faso. Average number of off farm activities in Koulikoro was 67% lower ($p < 0.01$) than in West-Central Burkina Faso where farmers

Table 2 Socioeconomic characteristics of farmers in the Sudano-Sahelian zone of Koulikoro (n = 103) in Mali and the West-Central region of Burkina Faso (n = 176)

Variables	Koulikoro Mali	West-Central BF	*p* value
Age (years)	55.00 (1.44)	60.00 (1.26)	< 0.01
Experience in farming (years)	39.65 (1.44)	50.22 (1.26)	< 0.01
Level of education (year)	3.17 (0.21)	4.21 (0.11)	< 0.01
Farm size (ha)	7.78 (0.59)	4.22 (0.24)	< 0.01
Fertilizer application (kg ha^{-1})	177.18 (189.37)	115.82 (150.84)	< 0.01
Household size	17.91 (1.57)	16.27 (1.02)	0.36
Average income (US$ $year^{-1}$)	384.68 (33.98)	333.00 (25.91)	0.23
Number of different crops grown	4.00 (0.14)	5.00 (0.10)	< 0.01
Number of farms owned	2.00 (0.12)	3.00 (0.09)	0.27
Number of off farm activities	3.00 (0.12)	1.00 (0.08)	< 0.01
Number of sheep owned	5.00 (1.00)	7.00 (0.66)	0.15
Number of trees/shrubs in farm	3.00 (0.21)	5.00 (0.24)	< 0.01
Yield (kg ha^{-1})	514.47 (36.84)	325.65 (18.77)	< 0.01
Cooperative membership (%)			
Yes	75.73	74.43	
No	4.27	25.57	
Access to credit (%)			
Yes	28.16	0.00	
No	71.84	100.00	
Access to extension service (%)			
Yes	75.73	62.50	
No	24.27	37.50	
Forage security (%)			
Yes	88.00	50.00	
No	12.00	50.00	

Numbers presented are means and respective standard errors of the mean in parenthesis. The exchange rate used rate for average income was 619 XOF to 1 US$

maintained 67% more trees and shrubs in their farms than in Koulikoro ($p < 0.01$). The two study locations had a similar percentage of farmers involved in farmer cooperatives, however, in Koulikoro 28% and 13% more farmers had access to credit and extension service respectively, than in West-Central Burkina Faso. Furthermore, 38% more of the farmers in Koulikoro felt forage secure than in West-Central Burkina Faso.

Socioeconomic characteristics influencing the adoption of Agroforestry technologies

The results of binary logistic regressions showed that average income, off farm activities, average number of owned sheep, cooperative membership, forage security, and maintained trees and shrubs enhanced the adoption of agroforestry technologies (Table 3). On the other hand, household size and crop yield hampered farmer adoption. As indicated by Nagelkerke's R^2, value, 38% of the variation in the adoption of agroforestry technology was explained by the afore-mentioned socioeconomic characteristics. A non-significant ($p = 0.33$) Hosmer–Lemeshow test showed that the data fitted the binomial logistic regression model well.

Adopted agroforestry technologies and tree species composition

On average 90% of farmers had adopted some parkland management approach (Fig. 2). The second most important agroforestry technology was the establishment of fodder banks which was practiced by 50% of the farmers in our study. West-Central Burkina Faso had 12% more farmers adopting windbreaks than in Koulikoro.

With an average use in 89% of the surveyed HHs, *Vitellaria paradoxa* C. F. Gaertn. was the most popular tree species maintained in both the Koulikoro

Table 3 Socio-economic factors determining the adoption of agroforestry technologies in the Sudano-Sahelian zone of Koulikoro in Mali and the West-Central region of Burkina Faso

Variables	Estimate (β)	Std. Error	Odds ratio (Expβ)	$Pr(>\|z\|)$
Level of education	0.113	0.087	1.120	0.195
Farm size	0.016	0.035	1.016	0.641
Household size	−0.045***	0.014	0.956	0.001
Average income	0.000*	0.000	1.000	0.016
Number of different crops grown	0.200	0.116	1.222	0.085
Number of farms owned	0.081	0.132	1.084	0.542
Number of off farm activities	0.345**	0.133	1.412	0.010
Number of owned sheep	0.057*	0.022	1.059	0.010
Tree/Shrubs maintained	0.302	0.067	1.352	0.000
Yield	−0.003***	0.001	0.997	0.001
Cooperative membership	0.729*	0.340	2.073	0.032
Access to credit	0.099	0.539	1.104	0.854
Access to extension service	0.587	0.321	1.798	0.067
Forage security	0.459*	0.181	1.583	0.011
Intercept	−3.492***	0.858	0.030	0.000
Model specifications				
Number of observations	279			
Percentage correct (%)	65			
Log likelihood	−144.572			
Hosmer–Lemeshow	0.328			
Nagelkerke R^2	0.384			

*Significant at $p<0.05$, **Significant at $p<0.01$, ***Significant at $p<0.001$

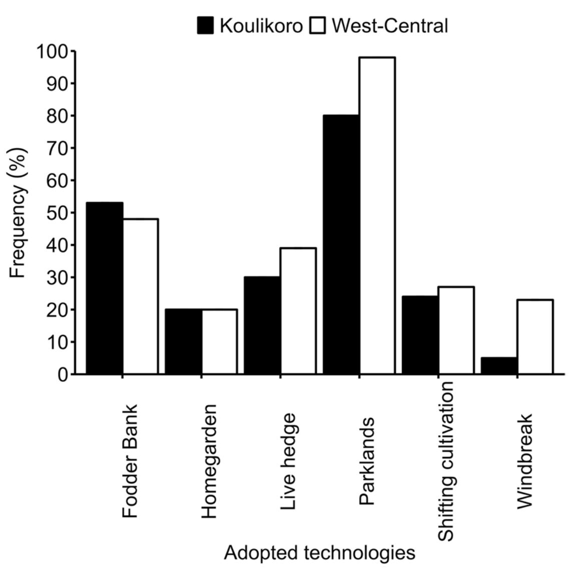

Fig. 2 Adopted agroforestry technologies in the Sudano-Sahelian zone of Koulikoro in Mali and the West-Central region of Burkina Faso

region of Mali and in West-Central Burkina Faso (Fig. 3). Asides from *V. paradoxa*, *Parkia biglobosa* (Jacq.) R.Br. ex G.Don., *Lannea microcarpa* Engl. & K.Krause., *Mangifera indica* L. and *Sclerocarya birrea* (A. Rich.) Hochst. were the most common tree and shrub species in both study regions. Whereas *P. biglobosa* ranked second most popular in Koulikoro, in West-Central Burkina Faso it ranked sixth.

Farmers at the different study sites were motivated by different reasons to maintain tree and shrub species (Fig. 4). Food security contributed on average 45% to the reported tree benefits in Koulikoro whereas it was 18% in West-Central Burkina Faso. Contrary to the latter location where soil fertility accounted for 29% of total tree benefits, in Koulikoro it only contributed 12%. For the same tree species, farmers in the different study locations were motivated by different reasons for maintaining them in their farms: whereas the majority of farmers in Koulikoro kept *L. microcarpa* for food security, in West-Central Burkina Faso it was mainly maintained for fuelwood and soil fertility. Similarly, *Adansonia digitata* L. and *Tamarindus indica* L. were important for 14% of the farmers

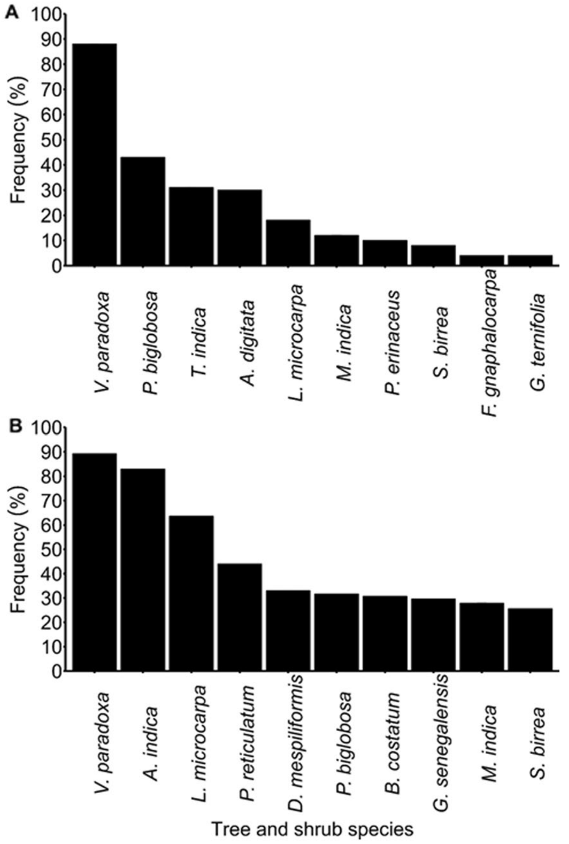

Fig. 3 Farmers' perceptions on the ten popular tree and shrub species maintained open-parkland of the Sudano-Sahelian zone of Koulikoro in Mali (**A**) and the West-Central region in Burkina Faso (**B**)

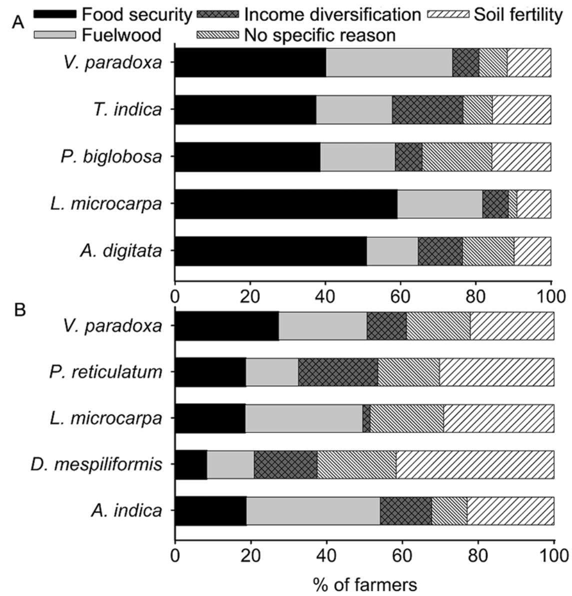

Fig. 4 Farmers' perceptions on positive attributes of five common tree species maintained in open-parkland of the Sudano-Sahelian zone of Koulikoro in Mali (**A**) and West-Central in Burkina Faso (**B**)

in Koulikoro and West-Central Burkina Faso, who cited income diversification as a driving force for its management.

Discussion

Socio-economic characteristics

The average farm size of 6 ha within our study is consistent with the average farm size of 5 ha for the parkland agroforestry in the Sahelian Region reported by Luedeling and Neufeldt (2012). This suggests that there is a high potential for agroforestry adoption whereby Tega and Bojago (2023) reported that large farm size hastens the adoption process. The fact that Koulikoro has more arable land available than West-Central Burkina Faso (Sounko and Mariko 2020) explains why here farm sizes are larger than in West-Central Burkina Faso. Another reason for bigger farm sizes in Koulikoro is the availability of labour, which is supported by our finding of large household sizes in Koulikoro. As a response to land scarcity, farmers in West-Central Burkina Faso (Roose et al. 1994; Hauchart 2007) grow a higher number of different crops on the same piece of land than those in Koulikoro. In the wake of increasing climatic variability in the study area, crop diversification may increase cropping systems' resilience and stability (Assogbadjo et al. 2012). Farmers in Koulikoro have higher crop yields than those in West-Central Burkina Faso because they apply more mineral fertilizer (Table 2). As farmers in West-Central Burkina Faso maintained more trees in their farms than those in Koulikoro, lower crop yields can also be attributed to increased competition for light and water between crops and trees. The adverse effect of resource competition between trees and crops in Parkland systems is well documented for the Sudano-Sahelian zone (Bazié et al. 2012; Sanou et al. 2012). However, this shortfall in crop yield is compensated by tree products such as fuelwood, timber, fruits, gums, and resins (Bayala et al. 2014, 2019). The provision of such multiple tree products becomes especially important when crops are out of season and /or during crop failures.

Socio-economic household characteristics influencing adoption of agroforestry technologies

The finding of household size hampering the adoption of agroforestry is similar to observations made by Pello et al. (2021) in arid and semi-arid regions of Kenya. One important intervention to help solve this problem is the integration of family planning education into agriculture extension services (Herrera et al. 2021). Similarly to Owombo and Idumah (2017) and Alabi et al. (2023) we found that a farmer's membership in a cooperative increases the probability of adopting agroforestry technology more than two-fold. Farmer associations offer opportunities for networking, which creates an enabling environment for knowledge and experience sharing. Additionally, in the dissemination of agricultural innovations members of cooperatives are the first beneficiaries. This suggests that prior to the introduction of an agroforestry practice in a locality without farmer cooperatives such structures merit to be established. As underlined by Zerihun et al. (2014) and Owombo & Idumah (2017), this study also found that farmers are twice as likely to adopt agroforestry technology if they have access to credit. The latter is very important especially in the Sudano-Sahelian zone where farmers heavily rely on external cash to purchase farm inputs during the cropping season (Sanou et al. 2019; Ibrahim and Nabage 2023). Access to extension services has been found to promote the adoption of sustainable agricultural practices (Owombo and Idumah 2017; Admasu and Jenberu 2022; Alabi et al. 2023), which confirms our observation that farmers with access to extension services have a two-fold higher likelihood of adopting agroforestry technologies. Farmer field visits are not only important to train farmers on tree nursery practices, planting, nurturing, and harvesting trees but it also helps to expose farmers to current innovations in agroforestry technologies. Our findings contradict Ibrahim and Nabage (2023) whereby in our study regions farmers' contact with research and development institutions was much closer. Since the Sudano-Sahelian zone is characterised by shortage of quality pasture (Ouédraogo et al. 2021), any land use guaranteeing fodder security, including agroforestry, likely hastens adoption. Our results suggest that farmers who engage in off-farm activities and have higher income will more easily adopt agroforestry technologies because their livelihood is not solely dependent on farm yields. Enhanced financial security may induce farmers to engage in long term investments allowing to generate higher crop yields in the future. This is consistent with the data of Gebru et al. (2018) on the adoption of agroforestry in Pakistan. According to Zerihun et al. (2014) the larger the number of livestock, the higher the likelihood of adoption of agroforestry technologies, a trend that has been also observed in our study. This is due to the availability of fodder from tree leaves especially during the dry season when other fodder sources are scarce. Large herd size also allows high amount of manure to be available for soil fertilization. The design of successful agroforestry technologies may require the inclusion of woody plants that offer substantial fodder all year round. Evidence shows that farmers who have a larger number of trees and shrubs in their croplands are more likely to implement agroforestry technologies as they have first-hand experience of the benefits of trees on their croplands. These benefits include soil fertility maintenance (Sanou et al. 2012), modification of the microclimate (Bayala et al. 2014), and income diversification (Guuroh et al. 2012; Nnko et al. 2022). The negative relationship between crop yields and the adoption of agroforestry technologies may be due to competition between trees and crops leading to lower crop yields (Bayala et al. 2012), which deters farmers from adopting these technologies. A the negative relationship between crop yields and agroforestry adoption has also been reported by Mwase et al. (2015) from South Africa. In the present study area farm sizes are small and farmers are resource poor, and thus likely more risk averse than elsewhere (Binam et al. 2015; Jha et al. 2021; Ibrahim and Nabage 2023). Hence the adoption of any technology which increases their risk of yield reduction will likely deter them from adopting. Tree crop competition can be reduced by pruning and pollarding. Pearl millet (*Pennisetum glaucum L.*) grain and biomass yield was reported to increase when *V. paradoxa* and *P. biglobosa* were pruned due to reduce above and below ground resource competition (Bayala et al. 2002, 2004). It may therefore be important to train farmers in such tree management practices to maximize benefits of agroforestry technologies.

Adoption of agroforestry technologies and tree species composition

Confirming earlier studies (Boffa 1999; Bayala et al. 2015), we observed that parklands are the most dominant land use in the Sudano-Sahelian zones of Mali and Burkina Faso reflecting many centuries of local traditions in semi-arid Africa (Neya et al. 2019; Sanou et al. 2022; Sehoubo et al. 2023). In these parklands, *V. paradoxa* was the most dominant tree species maintained in both, the Koulikoro region of Mali and in West-Central region of Burkina Faso. The dominance of *V. paradoxa* in our study confirms the report that it constitutes 80% of tree species in agroforestry systems in Mali (Nouvellet et al. 2006) and Burkina Faso (Bazié et al. 2018; Sanou et al. 2022). Ecologically this dominance can be explained by the shea tree's adaptation to even severe drought conditions due to it long tap root allowing for water uptake from deeperr soil layers (Azongnide et al. 2021). Economically, the fruits and butter from processed fruits of tree species serve as a food source due to their often high nutritional value (Neya et al. 2019; Ky-Dembele et al. 2021), and provide cash income when the products are sold (Guuroh et al. 2012; Bayala et al. 2014). Wood from the shea tree is suitable as a fuelwood, charcoal, and construction material (Bénagabou et al. 2017; Sanou et al. 2019). Through annual litterfall of 1.4 t DM ha^{-1}, the tree is an important source of organic matter for small scale resource poor farmers (Traore et al. 2004). Asides from *V. paradoxa*, the two study locations were also characterized by other tree species because of diverse farmer needs. The dominance of *A. digitata*, *P. biglobosa*, *M. indica* and *T. indica* in Koulikoro reflects farmers interest in food security (45%, Fig. 4) given their generally large household size (Table 2). Because farmers in West-Central Burkina Faso apply less mineral fertilizer, they prefer to maintain trees with high litterfall to sustain soil fertility (Abdoulaye and Boni 2020).

Conclusions

Our study showed that in the Sudano-Sahelian zone of West Africa, the key socio-economics characteristics and management practices determining agroforestry technology adoption by farmers are income, household size, number of off-farm activities, number of sheep owned, forage security, membership in a cooperative, crop yield and off-farm income. Parklands dominated by *V. paradoxa* are the dominant agroforestry system in the Sudano-Sahelian zone studied. Based on specific geographic location needs, farmers maintain the same tree species to satisfy diverse needs. Hence farmers in Koulikoro, Mali keep trees in their farms mainly for food security whereas those in West-Central Burkina Faso maintain them for soil fertility. Design and extension of agroforestry technologies should be adapted to local environmental and socio-economic conditions. This will guarantee that local farmers' immediate needs and expectations are better understood and effectively met.

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Author contributions S.F. and D.K.A. did the field work and wrote the main manuscript text, S.G. advised methodologically, S.L. and S.S. contrubuted with data and advise, and A.B. and S.G. conceptualised the study and secured funding. All authors reviewed the manuscript.

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Data availability Original data is made available by the authors upon reasonable request.

Declarations

Competing interests The authors declare no competing interests.

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