Factors influencing agropastoralists' adoption of fodder banks in the Central West Region of Burkina Faso, West Africa

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Research

Abstract

Background: In the Sahel region of sub-Saharan Africa, the reduction of natural rangelands due to an unbridled advance of the agricultural front has a negative impact on livestock production, which is mainly based on the rangeland ecosystems. Thus, there is a need for improvements to the livestock feeding system. One possible solution is the adoption of fodder production techniques, including fodder banks, by agropastoralists. This study examines the factors influencing agropastoralists' decisions to incorporate forage production (i.e., fodder banks) into their fields.

Methods: This study was carried out in the villages of Somé and Tiogo situated in the western-center region of Burkina Faso. The Participatory Analysis of Poverty and Livelihood Dynamics method was used to classify each farm household according to their wealth status using a stratified sampling approach. Data were collected from surveys of 240 agropastoralists using a questionnaire and an interview guide during January to December 2022. . Data were analyzed using principal component analysis and linear multiple regression.

Results: The results of the Bartlett sphericity test were significant ($\chi 2 = 2658.145$, $df = 190$, $p < 0.0001$). The three-component solution accounted for a total of 45% variance, with the three components contributing 27%, 12%, and 6%, respectively. Factor analysis summarized 25 indicators into three factors (i.e., reasons for participating in a forage production program, benefits and opportunities, and constraints).

These results show that agropastoralists' decisions to produce fodder in their fields are mainly due to their level of skills/knowledge on fodder production, their perceptions of benefits and opportunities related to the conservation of fodder trees in the fields, their membership of agropastoralist groups/associations, and constraints related to the establishment of fodder banks. Factors most associated with variations in agropastoralists' level of motivation for forage production and conservation include socio-economic and demographic factors such as gender, source of income,

household wealth status, household size, type of livestock, education, livestock herd size, membership of farmer and herder groups, ethnicity, marital status, land tenure, and livestock trend.

Conclusions: The success of projects seeking to popularize the adoption of fodder banks amongst agropastoralists is dependent upon adequate consideration of their determinants of innovative technology adoption.

Keywords: Forage conservation; forage crops; livestock production; Principal Component Analysis; semi-arid areas; socioeconomic and demographic attributes

Background

Livestock farming is a socio-economic activity of major importance globally, particularly in sub-Saharan Africa (Diallo 2004). In this region, the livelihood of the rural population is mainly dependent upon agriculture and livestock farming. These activities play an important socioeconomic role as they account for more than 11% of the region's gross domestic product (GDP) (Awa *et al.* 2004). Livestock farming in particular plays an important human, economic and environmental role in all West African countries (Vall *et al.* 2014). It is practiced by nearly 80% of rural families in these countries (Hiernaux et al. 2018), contributes to 40% of agricultural GDP and 15% of total GDP (Hiernaux *et al.* 2018), and plays a key role in the exploitation of a highly constrained rangeland environment through pastoralism (Assouma *et al.* 2019).

In Burkina Faso, a highly agriculture-oriented country in West Africa, livestock farming contributes 10-20% of GDP and is the second largest contributor to agricultural value adding after cotton (FAO 2018). It represents the fourth sub-sector in terms of contribution to export earnings, with an average share estimated at 10% over the period 2015-2020 (INSD 2020). Livestock farming also provides many goods and services to the Burkina Faso population, supporting livelihoods through income, food and nutrition, insurance, and energy (CILSS/RPCA 2010). However, several constraints are at the root of the low productivity of livestock farms in Burkina Faso. These are genetic, health, environmental and, above all, dietary constraints. Genetically, cattle farming is dominated by zebu, bulls, and crossbreeds with low production performance (Tellah et al. 2015). From a health perspective, African animal trypanosomiasis (AAT) remains the most important disease (Courtin et al. 2010). In addition to AAT, tick-borne diseases, foot-and-mouth disease, and mastitis cause huge losses to livestock and contribute to significant decreases in the animals' zootechnical performance (Pradere 2014).

Among the constraints to livestock farming, adequate feed is one of the limiting factors of livestock production (Sanon et al. 2014). Indeed, livestock systems in Sahelian countries such as Burkina Faso are generally pastoral insofar as livestock feed is mainly derived from grazing on rangelands (Hiernaux and Diawara 2014; Sanou *et al.* 2023). However, in warm regions, fodder production on natural pastures (herbaceous and woody) is closely dependent on rainfall (Lhoste 1993). Pastoral mobility, which is the major adaptation of livestock to variations in fodder availability, is increasingly restricted due to the expansion of crops and infrastructure, the scarcity of skilled labour, the risks of land legislation favouring individual ownership to the detriment of community usufruct (Oxby 2011), and the rise of civil insecurity (Bonnet 2013). The expansion of cultivated areas in relation to population growth, repeated droughts, erosion, and multifaceted landscape degradation caused by humans and animals, have also strongly contributed to the reduction of grazing areas in Burkina Faso (Kiema *et al.* 2012).

Many efforts have been made by agropastoralists and government advisors to enhance the production and conservation of fodder for livestock in the dry season (Aquino 2000), with a growing interest in the use of crop residues, and an emerging interest in herbaceous fodder crops. Agro-industrial by-products are a supplementary food resource (Ouattara 2014), and woody fodder species are an important fodder reserve for livestock in the dry season (Ouedraogo *et al.* 2019). However, these factors are not ensuring adequate feeding of livestock during the dry season. This is because crop residues, which are generally stored in poor conditions, are not sufficiently rich in nutrients (Savadogo *et al.* 1999), and most of the concentrates used (e.g., cottonseed meal, cottonseed, bran) are not always available and their costs make them inaccessible to all livestock farmers (Bamouni 2014).

Based on the above-described context, fodder banks appear as a potential solution. A fodder bank is an agroforestry technology based on woody forage species with high production of plant biomass, particularly species with high nutritional value (Figure 1). Fodder banks have many advantages: the valorization of aerial fodder; the availability of aerial fodder in all seasons; the improvement of the natural regeneration of forage plants; the reduction in the overexploitation of natural pastoral areas; sustainable increases in animal milk production, weight gain and manure; and maintaining plowing oxen in good shape at the start of the agricultural season (Kubkomawa *et al.* 2019). Despite the importance of fodder banks, their

adoption is not common in West Africa. Fodder banks have only been timidly adopted in agricultural practices in recent years for the following main reasons: the lack of balanced allocation of spaces, particularly for the benefit of livestock; the lack of control of extensions of cultivated areas; and the failure to produce a lucrative forage product from the year the bank. The aim of the study was to examine the factors influencing agropastoralists' decisions to incorporate the fodder bank/forage production system into their fields. We sought to identify the factors influencing the adoption of fodder banks and the main drivers related to the implementation of fodder banks by agropastoralists. The findings of this study can inform the development of more sustainable livestock farming systems whereby agropastoralists reduce their negative impacts on forest resources by incorporating forage production in their farmlands.

a. Fodder bank with *Leucena leucocephala*

b. fodder bank with *Andropogon gayanus*

c. fodder bank with *Vetiveria nigritana*

Figure 1. Examples of fodder banks in Burkina Faso-West Africa

Materials and Methods

Study area

This study was carried out in 2022 in the villages of Somé and Tiogo situated in the western-center region of Burkina Faso (Figure 2). The choice of these two villages was based on the presence of agricultural land use with an overexploitation of spaces, the non-existence of pastoral areas (particularly in the case of Somé where the agricultural front has considerably reduced the rangelands), and the presence of protected areas (i.e., the classified forest of Tiogo where grazing is prohibited) (Sanou *et al.* 2022). Thus, the availability of grazing land is reduced in both locations, and farmers therefore introduce their livestock into the protected Tiogo State Forest and the community forest of Saria.

The climate at Somé is characterized by marked seasonality with most precipitation occurring during the wet season lasting for 6 months from May to October. Based on data collected from an in situ mini-weather station at Saria, for the period 2006-2021, the average annual rainfall was 845 ± 92 mm with large inter-annual variability; and the number of rainy days per annum was 61 ± 7 days (Zida *et al.* 2023). The mean daily temperature varied from 30°C during the rainy season to 45°C in April and May. The major soil type is a ferric Lixisol which has a generally low fertility (Ouattara *et al.* 2006). The vegetation of the Saria site is characterized by savanna grasses, trees and shrubs and an agricultural landscape. The dominant woody species are *Parkia biglobosa*, *Vitellaria paradoxa*, *Lannea microcarpa*, *Faidherbia albida*, *Acacia albida*, *Guiera senegalensis*, and *Piliostigma reticulatum*. The main herbaceous species are *Loudetia togoensis*, *Walteria indica*, *Dactyloctenium aegyptium* and *Andropogon gayanus*.

The village of Tiogo is a surrounding zone of Tiogo State Forest. The Tiogo State Forest was designated by the colonial French administration in 1940 and covers an area of approximately 30,000 hectares. It is located along the only permanent river in the country (Mouhoun, formerly known as The Black Volta). Phytogeographically, Tiogo is situated in the Sudanian regional center of endemism in the transition from the north to the south Sudanian zone (Fontès & Guinko 1995). The Sudanian savanna is an area stretching across the African continent from Senegal in the west to the Ethiopian highlands in the east, which is characterized by a six-to-seven-month dry season and a mean annual rainfall of between 700 and 1200 mm (Breman & Kessler 1995).

The main livelihood activities of the residents include extensive livestock grazing and harvesting of various non-timber forest products such as fuelwood, thatching materials, poles for construction, and edible and medicinal plants. The main crops grown are *Sorghum bicolor*, *Panicum miliaceum*, *Zea mays*, *Arachis hypogaea*, *Vigna unguiculata* and *Gossypium hirsutum*. The people mainly engage in subsistence agriculture which is entirely rainfall-fed (The Little 2009). On the farms, the farmers retain some trees when clearing land for agriculture. Common species include *Adansonia digitata*, *Bombax costatum*, *Detarium microcarpum*, *Eucalyptus camaldulensis*, *Lannea microcarpum*, *Mangifera indica*, *Moringa oleifera*, *Sclerocarya birrea*, *Tamarindus indica*, *Gmelina arborea* and *Vitellaria paradoxa* (Sanou *et al.* 2017).

Data collection

Data were collected using a questionnaire and an interview guide during January to December 2022. Prior to the individual interviews with agropastoralists, focus group discussions and interviews were held with key informants. The focus group participants and key informants included leaders of local forest management cooperatives, local chiefs, government officials, and members of local non-governmental organizations and interest groups (Dolisca *et al*. 2006; Sanou *et al.* 2017). This methodological approach permits to identify endogenous knowledge on fodder bank innovations, the main drivers of fodder production in the field, and other potential agropastoralist factors to be investigated.

An initial farmer wealth ranking was also conducted to include a representative number of farmers from different wealth categories in the sample. The Participatory Analysis of Poverty and Livelihood Dynamics method was used to classify each farm household according to their wealth status using a stratified sampling approach (Krishna *et al*. 2004; Phiri *et al*. 2004). To do this, the household wealth status was ranked based on criteria determined by key informants. The order of the rankings that emerged was poor, moderate (not well-off), and rich. A total of 240 household heads were randomly selected (i.e., 120 in each village). To ensure an equal representation of wealth status groups in each village, 40 household heads from each of the wealth categories were selected. We focused on the heads of households because they are the decision-makers on matters related to land management and agricultural practices. Although men in Burkina Faso are more likely to be heads of households, their decisions on agricultural production are often influenced by the opinions of their wives and children (Sanou *et al.* 2017). Thus, the opinions of all members of the household are factored into the decision-making by the household head.

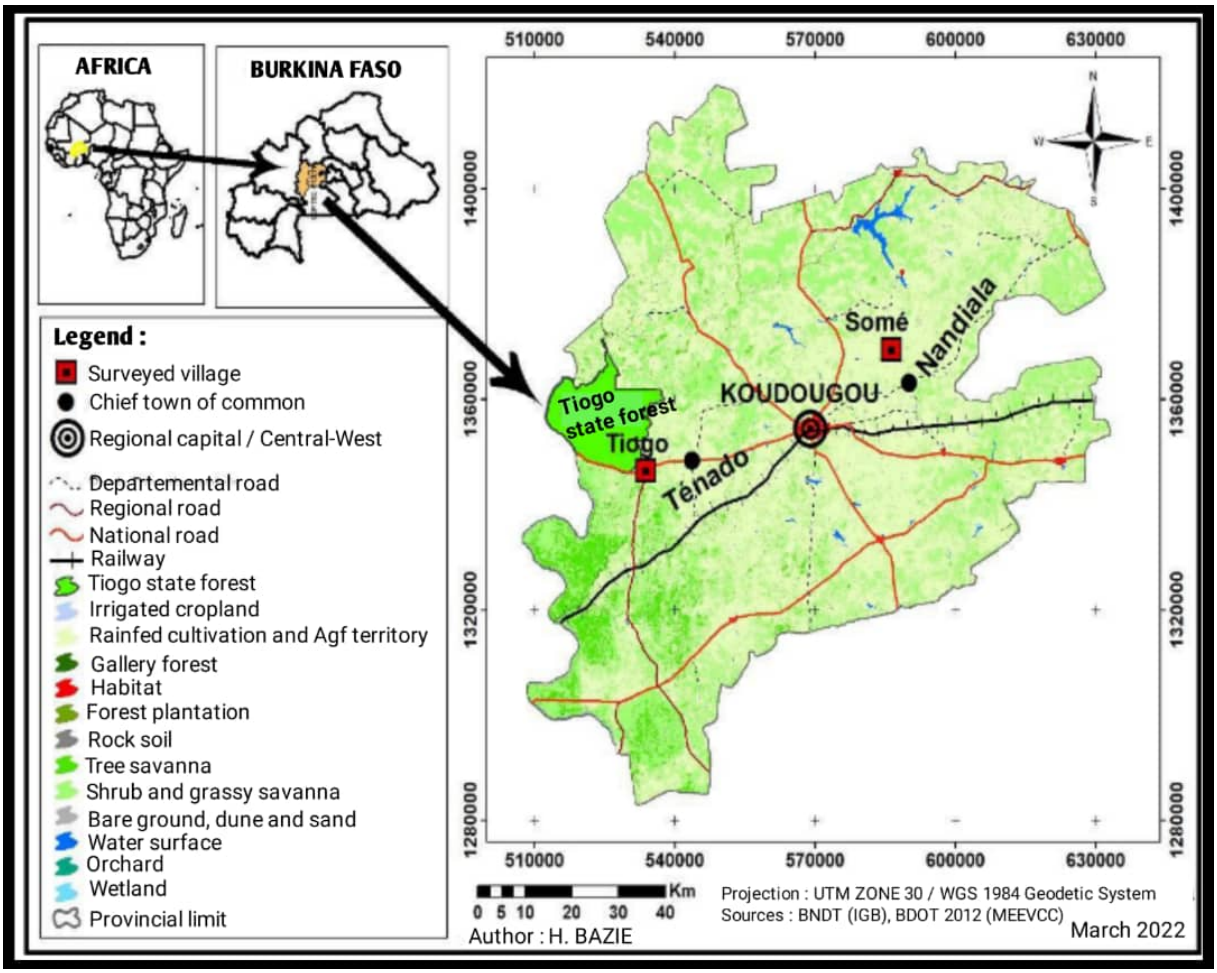

Figure 2. Location of the study areas in Burkina Faso

The surveys were supervised by a principal investigator to verify the accuracy of the data collected. During the interviews, demographic and socio-economic data were collected, including education level, gender, age, residency and land tenure status, income-generation from forestry activities, and household size, plus information on the receipt of technical assistance from the agropastoralists and government advisors or non-governmental organizations about the implementation of fodder banks. The agropastoralists were asked to rate the drivers of their fodder production and whether they had adopted fodder bank practices. For factors influencing the adoption of fodder bank technology, respondents were asked to rate them on a four-point Likert scale (Clason & Dormody 1994): 1: not important, 2: moderately important, 3: important, and 4: very important.

Data analysis

Quantitative data derived from the survey were analyzed using descriptive statistics (i.e., frequencies, percentages). Descriptive statistics were first used to summarize the profile of the respondents and information related to the production of forage on farmlands. Factor analysis was applied to identify the latent dimensions underlying indicators that determine the factors influencing the adoption of fodder banks (Table 1). This statistical approach consists of condensing information from a number of original variables into a set of smaller dimensions (factors) with minimal loss of information (Hair *et al*. 1998). Each factor was interpreted in terms of its loads, i.e., the strength of the correlations between the factor and the original variables (Tabachnick & Fidell 1996). Creating a small set of factors can reveal 'latent' relationship patterns among the variables. In this respect, a factor can be regarded as a single (unobserved) variable that reflects the variations in a set of variables with high loadings. Principal Component Analysis (PCA) was used to extract the factors, using Varimax rotation. This rotation ensures that the extracted factors are independent and not related to each other, while also maximizing the load on each variable and minimizing the burden on the other factors (Bryman & Cramer 2005).

To test the relevance of factor analysis to the dataset, the Bartlett sphericity test and the Kaiser-Meyer-Olkin sampling suitability measure (Kaiser, 1974) were applied. The overall measure of adequacy of the Kaiser-Meyer-Olkin sampling for

our dataset (0.886) was above the recommended threshold value of ≥0.5 (Kaiser 1974). This indicates that correlation models are relatively compact and that factor analysis can be applied to this dataset. The results of the Bartlett sphericity test were also significant ($\chi 2$ = 2658.145, df = 190, $p < 0.0001$). This suggests that factor analysis can be applied to the dataset, supporting the factorability of the correlation matrix.

Factors with an eigenvalue greater than 1.5 were considered significant according to the Kaiser criterion. The number of factors selected was guided by three decision rules: the Kaiser criterion, the inspection of the display graph, and the parallel Horn analysis (Horn 1965). Parallel analysis is one of the most accurate approaches to estimating the number of components. The size of the eigenvalues obtained by the PCA is compared with those obtained from a randomly generated dataset of the same size. Inspection of the display graph revealed a clear break after the third component, so three components were selected for further analysis (Pallant 2013). This was confirmed by the results of the parallel analysis, which showed only three components with eigenvalues exceeding the corresponding criterion value for a randomly generated data matrix of the same size (25 variables × 240 respondents).

Multiple linear regression analysis was used to explore the association between participation indicators and respondents' socio-economic and demographic characteristics. To estimate the subject's score for each factor, the Anderson-Rubin approach (Tabachnick & Fidell 1996) was applied. This is a method of estimating factor score coefficients, which ensures the orthogonality of the estimated factors. The resulting scores have a mean of 0.0 and a standard deviation of 1.0 and are uncorrelated. The following model was developed using ordinary least squares regression.

$$Facteur\ i = Constant + \beta 1RIM + \beta 2SEX + \beta 3GRE + \beta 4CLA + \beta 5NIE + \beta 6ETC + \beta 7STR + \beta 8DUO + \beta SUT + \beta 10TAM + \beta 11PMH + \beta 12AST + \varepsilon$$

$$Facteur\ i = Constant + \beta 1RIM + \beta 2SEX + \beta 3GRE + \beta 4CLA + \beta 5NIE + \beta 6ETC + \beta 7STR + \beta 8DUO + \beta SUT + \beta 10TAM + \beta 11PMH + \beta 12AST + \varepsilon$$

Where Factor i represents the factors found from the factor analysis;
β_1 to β_{12} represent the coefficients of socio-economic and demographic variables; and Ɛ is the error term that is distributed independently and identically.
Testing of dataset characteristics that may affect the reliability of the estimates, including specification, multicollinearity, and spatial autocorrelation, indicated that MCO regression assumptions were not violated.

Table 1. Names, abbreviations and scales of the variables included in the factor analysis

No.	Names of the variables	Label	Scale
1	Need for quality livestock products	BPEQ	[1-4]
2	Access to credit	ACAC	[1-4]
3	Land tenure	REFO	[1-4]
4	Lack of knowledge on fodder production and storage techniques	MTPC	[1-4]
5	Forage needs	BEDF	[1-4]
6	Existence of a livestock market	EXMB	[1-4]
7	Field fertility	FEDC	[1-4]
8	Environmental reasons	RAEN	[1-4]
9	Lack of water source	INPE	[1-4]
10	Participation in the Livestock Production Program	PAPA	[1-4]
11	Climatic conditions of the site	COCS	[1-4]
12	Attitude towards the production, and conservation of forage trees	ACAF	[1-4]
13	Quality of the site	QUDS	[1-4]
14	Straw requirement	BEPA	[1-4]
15	Motivation	MOTI	[1-4]
16	Knowledge of forage tree conservation	CCAF	[1-4]
17	Perception of opportunities	PEDO	[1-4]
18	Technical assistance	ASTE	[1-4]
19	Afforestation of the landscape	BODP	[1-4]
20	Member of an agropastoralist group	MEGA	[1-4]

21	Distance from the market	DIRM	[1-4]
22	Need for forest products	BEPF	[1-4]
23	Difficulties in accessing seeds	DIAS	[1-4]
24	Characteristics of the Agricultural Land	CATA	[1-4]
25	Type of Breeding	TYEL	[1-4]

Results

Profile of respondents

The socio-economic and demographic characteristics of the respondents are presented in Table 2. The majority of respondents were male (62.08%) and 30.83% were between 40 and 50 years old. The highest incidence of household size was between 5 and 10 family members (44.58%). More than half (59.17%) of the respondents were from the Mossi, and the majority were Indigenous (81.67%) and married (90%). Non-religious people accounted for only 29.17%. Most (74.17%) of those surveyed had no formal education, only a few (8.75%) had completed secondary education and only 5% said they had received agricultural training. The main source of income for respondents was agriculture combined with livestock (78.75%). More than half (56.25%) of the herders practiced a semi-intensive livestock system, with only 12% having greater than 30 cattle. Nearly 80% of those surveyed said they were increasing their cattle numbers, and only 8.75% said they had joined a breeders' association. Only 7.50% of the respondents had a cultivated area of between 5 and 10 ha, the majority of which (62.92%) were acquired from inheritance. The plough and tractor were the most common means of cultivation in the surveyed areas (59.17%). Up to 60% of respondents said they had received technical assistance, the main ones being livestock vaccination and livestock counselling.

Table 2. Profile of the respondents

Variables		**Frequencies**	**Percentage (%)**
Gender	Female	91	37.92
	Male	149	62.08
Age group	[20-29]	35	14.58
	[30-39	45	18.75
	[40-49]	74	30.83
	[50-59]	43	17.92
	[60-69]	43	17.92
Ethnic group	Gourounsi	69	28.75
	Mossi	142	59.17
	Fulani	24	10.00
	Other	5	2.08
Education level	Illiterate	178	74.17
	Primary education	16	6.67
	Secondary education	21	8.75
	Adult Education	13	5.42
	Agricultural training	12	5.00
Marital status	Married	226	94.17
	Single/Widowed	14	5.83
Residency status	Native	196	81.67
	Migrant	44	18.33
Religion	Religious	170	70.83
	Non-religious	70	29.17
Duration of occupancy	[20-29]	51	21.25
	[30-39	43	17.92
	[40-49]	66	27.50
	[50-59]	39	16.25
	[60-69]	41	17.08
Household wealth	Poor	80	33.33
	Moderate	80	33.33

	Rich	80	33.33
Livestock system	Intensive	64	26.67
	Extensive	41	17.08
	Semi-intensive	135	56.25
Livestock trend	Increasing	190	79.17
	Descending	17	7.08
	Stable	33	13.75
Livestock size	[0-10]	116	48.33
	[10-20]	73	30.42
	[20-30]	21	8.75
	>30	30	12.50
Size of farm (ha)	<1 ha	47	19.58
	[1-2]	106	44.17
	[3 -4]	69	28.75
	[5-10[	18	7.50
Land tenure	Inheritance	151	62.92
	Loan	1	0.42
	Gift	86	35.83
	Purchase	2	0.83
Cultivation tools	Plough	98	40.83
	Plough+Tractor	142	59.17
Household Size/	< 5	34	14.17
	[5-10]	107	44.58
	[11-15]	45	18.75
	[16- 20]	35	14.58
	>20	19	7.92
Source of Income	Agriculture	34	14.17
	Agriculture+Animal Husbandry	189	78.75
	Agriculture+Livestock+Migration	17	7.08
Technical assistance	Yes	144	60.00
	No	96	40.00
Type of technical assistance	None	95	39.58
	ESC/DRS+Soil Amendment Techniques	12	5.00
	Livestock Vaccination + Livestock Advice	133	55.42
Membership in a breeders' association	Yes	65	27.08
	No	175	72.91
Membership in an association of livestock producers who produce fodder	Yes	21	8.75
	No	219	91.25
Membership in a farmers' association	Yes	76	31.66
	No	164	38.33

Factors influencing agropastoralist decisions on the management and protection of fodder banks

The correlation matrix results revealed that many coefficients had a value of 0.3 and above. The Kaiser-Meyer-Olkin value was 0.886, which exceeds the recommended level of 0.5. The results of the Bartlett sphericity test were also significant ($\chi 2 = 2658.145$, df = 190, $p < 0.0001$). The three-component solution accounted for a total of 45% variance, with the three components contributing 27%, 12%, and 6%, respectively (Table 3). The varimax rotation solution revealed the presence of a simple structure, with three components showing a number of high loads and all variables only substantially loading on a single component. There was a weak positive correlation between the three components ($r^2=0.4$).

Factor analysis summarized 25 indicators into three factors (i.e., reasons for participating in a forage production program, benefits and opportunities, and constraints) that accounted for 45.6% of the total variance (Table 3). The results showed that the commonalities representing the overall importance of each variable in the PCA were low (<0.5, i.e., variables for

which common factors explain little variance) for site quality, need for straw, distance to market, and need for forest products. This implies that these indicators are not related to the factors influencing agropastoralists' decisions, represented little of the common variability with the other variables, and contributed little to the PCA solution. The relatively high values of the other communities indicate that the factors explained the variation in the original variables. A variable with high commonality indicated a significant correlation between this variable and the other variables contributing to a common factor.

The dominant variables for reasons for participation in a forage production program accounted for 27% of the variation. This first factor consisted of fourteen indicators. The high importance (0.791) of the first variable (BPEQ) could play an important role in the adoption of fodder bank technology. Other indicators include access to credit, land tenure, lack of knowledge of fodder production and conservation techniques, need for fodder, existence of a livestock market, fertilization of fields, environmental reasons, lack of a water point, participation in the livestock production program, climatic conditions of the site, attitude towards the conservation of fodder trees, the quality of the site, and the need for straw.

The second factor (i.e., benefits and opportunities) explained 12.22% of the variation with indicators such as motivation, knowledge on the conservation of fodder trees, perception of opportunities, technical assistance, afforestation of the landscape, belonging to a group of agropastoralists, distance to market, and the need for forest products.

The third factor (i.e., constraints) explained 6.639% of the variation with three indicators, namely difficulty of access to seeds, characteristics of agricultural land, and type of livestock.

Table 3. Schema and structure for PCA with Varimax rotation of the three-factor solution of indicators of agropastoralists' participation in forage production and conservation

Description	Factor 1	Factor 2	Factor 3	Communality
Skills/knowledge of fodder production and animal husbandry				
Need for Quality Livestock Products (BPEQ)	**0.791**	0.046	-0.026	0.589
Access to Credit (IBAC)	**0.769**	0.132	-0.062	0.344
Land tenure (REFO)	**0.753**	-0.034	-0.046	0.638
Lack of knowledge of forage production and conservation techniques (MTPC)	**0.746**	0.160	0.115	0.374
Forage requirement (BEDF)	**0.725**	0.023	0.041	0.536
Existence of a livestock market (EXMB)	**0.721**	0.085	-0.041	0.198
Field Fertilization (FEDC)	**0.653**	0.014	-0.081	0.379
Environmental Reasons (RAEN)	**0.610**	0.160	0.088	0.344
Water Point Deficiency (INPE)	**0.583**	0.191	-0.006	0.342
Participation in the Animal Program (PAPA)	**0.580**	-0.053	-0.045	0.585
Site Climatic Conditions (COCS)	**0.579**	-0.032	-0.133	0.241
Attitude Towards Forage Tree Conservation (ACFO)	**0.552**	-0.024	-0.188	0.441
Site Quality (QUDS)	-0.010	-0.032	-0.133	0.810
Need for straw (BEPA)	0.059	0.085	-0.041	0.389
Benefits & Opportunities				
Motivation (MOTI)	0.028	**0.602**	-0.006	0.484
Forage Tree Conservation Knowledge (FCC)	-0.013	**0.597**	-0.047	0.514
Perception of Opportunity (PEDO)	0.100	**0.565**	0.115	0.367
Technical Assistance (ASTE)	0.000	**0.559**	-0.006	0.655
Landscape Afforestation (BODP)	0.036	**0.517**	0.088	0.396
Member of an agropastoralist group (MEGA)	-0.038	**0.510**	-0.184	0.263
Distance to Market (DIRM)	-0.061	0.163	0.001	0.398
Forest Products Requirement (BEPF)	0.408	0.415	-0.105	0.494
Constraints				
Difficulties in accessing seeds (DIAS)	0.218	-0.010	**0.576**	0.669
Agricultural Land Characteristics (CATA)	0.090	0.014	**0.417**	0.519
Type of Livestock (TYEL)	0.185	0.071	**0.398**	0.440

Eigenvalue	6.693	3.055	**1.660**	11.408
Explained variance (%)	26.774	12.221	6.639	45.634

Note: Varimax rotation method with Kaiser normalization. The rotation converged after five iterations (N = 240) and major loads (with a value greater than 0.50 in absolute terms) for each item in the variable are highlighted in bold. The measure of commonality is the multiple correlation coefficient squared (SMC). Reasons for participating in a forage production program. benefits and opportunities. and constraints are names that the researchers developed based on the interpretation of the loads in each factor.

Do agropastoralists participate in fodder production and conservation programs according to their socio-economic and demographic attributes?

Multiple regression models developed to determine the relationships between respondents' socio-economic and demographic attributes and their potential to participate in fodder bank programs revealed that several variables (i.e., gender, education, ethnicity, marital status, source of income, land tenure, wealth status, household size, livestock type, herd trend, herd size, and herd group membership) were statistically significant for all three participation indicators (Table 4). The adjusted R^2 values of socio-economic and demographic attributes were low (0.308, 0.347 and 0.226) for reasons for participation in a forage production program, benefits and opportunities, and constraints, respectively. This indicates that the model explains little variability around the responses of the data means. Gender, source of income, wealth status, household size, and type of livestock were significant in terms of reasons for participation in a forage production program (factor 1). A significant relationship between gender, education, household size, herd size, herder group membership, and farmer group membership were found for benefits and opportunities (factor 2). For constraints (factor 3), significant relationships were found between ethnicity, marital status, land tenure, household size, herd trend, and belonging to a farming group.

Table 4. Normalized Beta Regression Coefficients Estimated from the Last Variable Equation for Participation in Forage Production and Conservation Programs

	Factor 1		**Factor 2**		**Factor 3**	
	Value of t		**Value of t**		**Value of t**	
Constant		-2.028		-2.137		0.967
Gender	0.244***	2.921	0.230	2.839***	-0.073	-0.830
Ethnic group	-0.086	-1.279	-0.049	-0.756	-0.196***	-2.755
Age	-0.127	-0.836	-0.037	-0.249	-0.178	-1.113
Education	0.074	1.200	-0.138	-2.306**	-0.105	-1.607
Marriage status	-0.036	-0.566	0.031	0.494	-0.121**	-1.774
Religion	-0.097	-1.531	0.103	1.676	-0.094	-1.404
Residency Status	0.028	0.375	-0.004	-0.060	-0.031	-0.396
Duration of occupancy	0.086	0.535	-0.127	-0.813	0.144	0.849
Source of Income	0.159**	2.125	0.058	0.799	0.064	0.807
Land Tenure	0.113	1.886	0.016	0.273	0.167***	2.635
Farm size	0.026	0.347	0.062	0850	0.081	1.014
Wealth status	-0.227***	-3.313	0.073	1.099	0.261***	3.597
Household Size	0.179**	2.165	-0.176	-2.195**	-0.328***	-3.745
Male/Female Ratio	0.048	0.875	-0.009	-0.169	0.083	1.414
Type of breeding	0.212***	3.212	-0.019	-0.304	-0.031	-0.441
Livestock Trend	-0.036	-0.607	0.078	1.373	0.158**	2.550
Livestock size	-0.017	-0.245	0.219	3.299***	0.043	0.592
Assistance technique	0.099	1.429	0.094	1.404	-0.028	-0.387
Membership in a breeders' group	0.013	0.194	0.191	3.027***	-0.064	-0.927
Membership in a forage production group	-0.009	-0.160	0.040	0.691	0.030	0.485
Membership in a farmer's group	-0.215***	-3.651	0.265	4.616***	0.209***	3.343
Adjusted R^2	0.308		0.347		0.226	

Note: Statistically significant estimates are indicated by asterisks **P < 0.05; ***P < 0.005. Factor 1: Skills/knowledge on forage production and livestock activity. Factor 2: Advantages and opportunities. constraints; Factor 3: Constraints.

Discussion

Factors influencing agropastoralists' decisions in the implementation of fodder banks

The high importance (0.791) of the variable (BPEQ: need for quality livestock products) for reasons for participation in a forage production program could play an important role in the adoption of fodder bank technology. Improving livestock production and productivity to obtain good quality livestock products could motivate the adoption of improved forage technologies (Bashe *et al*. 2018). Other variables (i.e., access to credit, land tenure, lack of knowledge of fodder production and conservation techniques, need for fodder, existence of a livestock market, fertilization of fields, environmental reasons, lack of a water point, participation in the livestock production program, climatic conditions of the site, and attitude towards the conservation of fodder trees, the quality of the site, and the need for straw) show that agropastoralists can adopt fodder bank technology to achieve a targeted interest. Our results corroborated with several authors (e.g., Bashe *et al.* 2018; Montcho *et al.* 2018; Fenetahun *et al*. 2019). For example, Montcho *et al*., (2018) had found that factors such as access to agricultural credit, belonging to a farming group, and farmers' perception positively affect the adoption rate of innovative technologies.

For factor 2, the variables (i.e., motivation, knowledge of forage tree conservation, perception of opportunities, technical assistance, afforestation of the landscape, membership of an agropastoralist group, distance to market, and the need for forest products) indicate that the benefits and opportunities available to agropastoralists can influence their decisions on the management and protection of fodder banks.

The dominant variables of factor 3 (i.e., difficulties in accessing seeds, characteristics of agricultural land, and type of livestock) show that certain constraints can influence the adoption of fodder bank technology. Indeed, difficulties in accessing seeds are one of the major obstacles to the introduction of fodder crops into production systems (Hamadou *et al*. 2005).

Does agropastoralists' participation in fodder production and conservation programs depend on their socio-economic and demographic attributes?

Multiple regression models developed to determine the relationships between respondents' socio-economic and demographic attributes and their potential to participate in fodder bank programs revealed that several variables (i.e., gender, education, ethnicity, marital status, source of income, land tenure, wealth status, household size, livestock type, herd trend, herd size, and membership in a herder and farmer group) were statistically significant for all three participation indicators. These results are similar to those of several other studies (e.g., Mabah *et al*. 2013, Sodjinou *et al*. 2015). These authors have shown the influence of socio-economic and demographic factors on the adoption of agricultural innovations and on the integration of new practices in livestock farming. Indeed, household size positively and significantly affects the likelihood of adoption of improved forage technology (Bashe *et al*. 2018). This result could be explained by the fact that improved practices are labour intensive. As a result, households with a relatively large labour force use technology on their agricultural plots more than others.

For the benefits and opportunities associated with the adoption of fodder bank technology, ruminant herd size was significant. This result indicates that the larger the ruminant herd size, the more an agropastoralist will adopt forage technology to feed their animals and increase their production (Montcho *et al*. 2018). The farmer's membership or non-association variable also plays a decisive role in the adoption of fodder crops. Indeed, it is the means through which extension services, development projects and non-governmental organizations (NGOs) working in the sector come into contact with agropastoralists for awareness raising and technology dissemination (Hamadou *et al.* 2005).

The variables ethnicity, marital status, land tenure, household size, herd trend, and membership in a farming group explain the influence of constraints on decisions to adopt fodder banks. These results are similar with those of Napon *et al.* (2020) who indicate that the size of the household and the ethnic group of the individuals surveyed are significantly associated with the practice of intensification techniques.

Conclusion

The practice of blessings plays an important role in the health care of the investigated communities, even in the…

The objective of this study was to examine the factors influencing agropastoralists' decisions to incorporate forage production (i.e., fodder banks) into their fields. The results showed that three main indicators influence agropastoralists' adoption of fodder production in the central-western region of Burkina Faso - Factor 1: skills and knowledge related to

fodder production and livestock management; Factor 2: perceived benefits and opportunities of fodder banks; and Factor 3: constraints. Gender, education, ethnic group, marital status, source of income, land tenure, wealth status, household size, type of livestock, herd trend, herd size, and membership of a herder and farmer group are socio-economic and demographic attributes of respondents that were significantly associated with these three indicators. Non-government organizations and other development project implementers can facilitate the practice of fodder cultivation by facilitating access to inputs (such as seeds of fodder species) and enriching the flora of community forests by planting woody fodder species in degraded areas.

Declarations

List of abbreviations: FONRID-Fonds National pour la Recherche, l'Innovation et le Développement ; NGO- non-governmental organizations

Ethics approval and consent to participate: Individual consent to participate in the study was obtained prior to the administration of the questionnaire.

Consent for publication: Not applicable

Availability of data and materials: This study's analyzed data are available upon request by the journal

Competing interests: The authors declare that there is no conflict of interest.

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Author contributions: LS, JD, FB, SD, DNET, MY conceived the work with advice from KL, SP. SL collected and processed the data. SL and SP performed the statistical analyses. SL drafted the manuscript with contributions from DJ, BF, DS, TDNE, YM, SP, KJ. All authors read and approved the final manuscript.

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Literature cited

Aquino P. 2000. Agropastoralism in northern Burkina Faso (Soum province): a remarkable but still incomplete evolution. Autrepart 15: 29-47. doi: https://www.researchgate.net/publication/32968361.

Assouma MH, Lecomte P, Corniaux C, Hiernaux P, Ickowicz A, Vayssières J.2019. Pastoral livestock territories in the Sahel: a carbon footprint with an unexpected potential for climate change mitigation. Montpellier, CIRAD, Perspective 52. doi: 10.19182/agritrop/00082.

Awa DN, Njoya A, Mopaté YL, Ndomadji JA, Onana J, Awa AA, Tama AN, Djoumessi M, Loko BD, Bechir AB, Delafosse A, Maho A. 2004. Constraints, opportunities and evolution of livestock systems in the semi-arid zones of the Central African savannahs. Cahiers d'Agricultures 13:331-340. https://revues.cirad.fr/index.php/cahiers-agricultures/article/view/30452

Bamouni I. 2016. Diagnostic study of fodder crop technologies within agropastoral farms in the province of Houet, Diploma in Rural Development Design Engineering, Polytechnic University of Bobo Dioulasso (UPB), July 2016, Bobo Dioulasso, Burkina Faso, 54p.

Bashe A, Bassa Z, Tyohannis S. 2018. The determinants of probability in improved forage technology adoption in wolaita zone: the case of sodo zuria district, southern nations and nationalities peoples state of Ethiopia. Open Access Journal of Science 2(4): 228-231. doi: 10.15406/oajs.2018.02.00078

Bonnet B. 2013. Pastoral vulnerability and public policies to secure pastoral mobility in the Sahel. Developing Worlds 164(4): 71-91. doi: http://doi.org/10.3917/med.164.0071.

Bryman A, Cramer D. 2005. Quantitative Data Analysis with SPSS 12 and 13. A Guide for Social Scientists. Routledge, East Sussesx.

Cesar J, Ehouinsou M, Gouro A. 2004. Fodder production in the tropics and advice to livestock farmers. 48 p.

Clason DL, Dormody TJ. 1994. Analyzing data measured by individual Likert-type items. Journal of Agricultural Education 35:31-35.

Courtin F, Rayaissé JB, Tamboura I, Serdébéogo O, Koudougou Z, Solano P, Sidibé I. 2010. Updating the Northern Tsetse Limit in Burkina Faso (1949-2009). Impact of Global Change. International Journal of Environmental Research and Public Health 7:1708-1719.

Dolisca F, Carter DR, McDaniel JM, Shannon DA, Jolly CM. 2006. Factors influencing farmers' participation in forestry management programs: A case study from Haiti. Forest Ecology and Management 324-331.

Elbasha E, Thornton PK Tarawali G. 1999. Ex-post economic evaluation of fodder crops in West Africa. ILRI Impact Assessment Series, No. 2. ILRI (International Livestock Research Institute), Nairobi, Kenya,72 pp.

FAO 2018. The Impact of Sheep and Poultry Production Systems on Livelihoods in Burkina Faso, 9p.

Fenetahun F., XU X., & WANG X. D. 2019. Determinants of pastoral communities for adoption of forage production technology in Yabello rangeland, Southern Ethiopia. Academia Journal of Agricultural Research 7(6): 125-132. doi: 10.15413/ajar.2019.0701

GWP/AO 2010. Inventory of local populations' climate change adaptation strategies and exchange of experiences and good practices between the different regions in Burkina Faso, 85p

Hair J.F.J., Anderson R.E., Tatham R.L. & Black W.C. 1998. Multivariate Data Analysis, 5th ed. Prentice Hall, Upper Saddle River, NJ.

Hamadou S., Kamuanga M., Abdoulaye A T. & Lowenberg-Deboer J. 2005. Factors Affecting the Adoption of Forage Crops in Peri-Urban Dairy Farms in Bobo-Dioulasso, Burkina Faso. Tropicultura 23(1): 29-35.

Hiernaux P, Diawara M. O. 2014. Livestock recyclers that promote the sustainability of smallholder farms. Rural 21 (04): 9-11.

Hiernaux P, Diawara MO, Assouma MH. 2018. In the Sahel, maintaining pastoral livestock to adapt to climate change: Transhumance, which plays an essential role in the adaptation of herds to climatic variations in the Sahel, is now threatened. https://www.lemonde.fr/afrique /article Au-sahel-maintain-l'élevage-pastoral-pour s'adapt-au-changement climat 5388932_3212-htlm.

Horn JL. 1965. A rationale and test for the number of factors in factor analysis. Psychometrika 30:179-185.

Kaiser H. 1974. An index of factorial simplicity. Psychometrika 39:31-36.

Kiema A, Sawadogo I, Ouédraogo T, Nianogo AJ. 2012. Fodder exploitation strategies by livestock farmers in the Sahelian zone of Burkina Faso. International Journal of Biological and Chemical Sciences 6(4): 1492-1505. doi: 10.4314/ijbcs.v6i4.8.

Krishna A, Kristjanson P, Radeny M, Nindo W. 2004. Escaping poverty and becoming poor in twenty Kenyan villages. Journal of Human Development 5: 211-226.

Kubkomawa H.I, Kenneth-Chukwu A.M, Krumah J.L, Yerima I.N, Audu Z, Nafarnda W.D. 2019. Fodder bank establishment and management for dry season maintenance of small-scale livestock industry; A review. Nigerian Journal of Animal Production 46(4):211-221.

Laouali A. 2014. Contribution to the study of the dynamics of pastoral livestock farming in Niger: the case of the Diffa region, 194p.

Lhoste P, Soltner D, Dolle V, Rousseau J. 1993. Zootechnics of Warm Regions: Husbandry Systems, Manual and Accurate Husbandry Collection. CIRAD, 288 p.

Mabah TGL, Havard M, Temple L. 2013. Socio-economic and institutional determinants of the adoption of technical innovations in maize production in western Cameroon. Tropicultura 31(2): 137-142.

Ministry of Animal Resources.2010. Statistics of the livestock sector in Burkina Faso, 57p.

Montcho M, Babatounde S, Aboh AB, Houndonougbo F, Chrysostome AMC. 2018. Perception and adoption of technical innovations in ruminant feeding in Benin. African Agronomy 30(1): 31-45.

Napon K, Augustine Ayantunde A, Da DEC. 2020. Intensification of agropastoral and gender production in the Sudano-Sahelian sector in Burkina Faso. International Journal of Biological and Chemical Sciences 14(3): 800-815. doi: 10.4314/ijbcs.v14i3.13.

Ouedraogo S, Sanou L., Savadogo P, Sana Y, Kabore-Zoungrana CY. 2019. Temporal availability and nutritional value of jujube fodder in the Sudanian zone of Burkina Faso, West Africa. Science et Technique, Sciences naturelles appliquées 38(2):105-116

Ouattara KA. 2014. Inventory and characterization of livestock feed resources in the Bobo Dioulasso area and production of fodder crops, Master in Animal Production, Polytechnic University of Bobo Dioulasso (UPB), Bobo Dioulasso, Burkina Faso, 70p.

Oxby C. 2011. 'Will the 2010 Code Pastoral' Help Herders in Central Niger? Land Rights and Land Use Strategies in the Grasslands of Abalak and Dakoro Departments. Nomadic Peoples 15 (2): 53-81. doi: https://www.jstor.org/stable/43133007.

Pallant J. 2013. SPSS Survival Manual: A Step by Step Guide to Data Analysis using IBM SPSS, 5th ed. The McGraw Hill companies, England p. 353.

Penning de Vries FWT, Djitéye, MA.1982. The productivity of Sahelian pastures. A study of soils, vegetation and the exploitation of this natural resource (1st edition). Wageningen: PUDOC, 525 p.

Phiri D, Franze LS, Mafongoya P, Jere I, Katanga R, Phiri S.2004. Who is using the new technology? The association of wealth status and gender with the planting of improved tree fallows in Eastern Province, Zambia. Agricultural Systems 79: 131-144.

Pradère JP. 2014. Improving animal health and livestock productivity to reduce poverty. Revue scientifique et technique. 33(3): 723-734.

Sanon HO, Savadogo M, Tamboura HH, Kanwé BA. 2014. Characterization of production systems and fodder resources in a test terroir in the Sudanian zone of Burkina Faso. VertigO - the electronic journal in environmental sciences 14 (2). doi: https://id.erudit.org/iderudit/1034700ar.

Sanou L, Savadogo P, Ezebilo E E, Thiombiano A. 2017. Drivers of farmers' decisions to adopt agroforestry: Evidence from the Sudanian savanna zone, Burkina Faso. Renewable Agriculture and Food Systems 1-18. doi: 10.1017/S1742170517000369.

Sanou L, Savadogo P, Zida D, Thiombiano A. 2022. Variation in soil seed bank and relationship with aboveground vegetation across microhabitats in a savanna-woodland of West Africa. Nordic Journal of Botany e03304:1-15. doi: 10.1111/njb.03304

Sanou L, Ouédraogo S, Koala J, Delma J, Thiombiano A.2023. Productivité intra-annuelle des parcours naturels dans la zone sahélienne du Burkina Faso. Revue d'élevage et de médecine vétérinaire des pays tropicaux. doi: 10.19182/remvt.36966

Sib O. 2018. Co-design of an innovative fodder system: introduction of shrub fodder banks in dairy farms in western Burkina Faso. Ph.D. Thesis in Rural Development, Doctoral School of Natural Science and Agronomy / NAZI BONI University, Bobo-Dioulasso (Burkina Faso), 125p.

Sodjinou E, Glin LC, Nicolay G, Tovignana S, Hinvi J. 2015. Socioeconomic determinant of organic cotton adoption in Benin, West Africa. Agricultural and Food Economics 3: 12. doi: 10.1186/s40100-015-0030-9.

Tabachnick B.G. & Fidell L.S. (1996). Using Multivariate Statistics. Harper Collins College Publishers, New York.

Tellah M, Mbaindingatoloum FM, Mopate Logtene Y, Boly H. 2015. Age at first calving and calving interval of four cattle breeds in the peri-urban area of N'Djamena, Chad. Afrique Science 11 (3): 229-240.

Vall E, Salgado P, Corniaux C, Blanchard M, Dutilly C, Alary V. 2014. Changes and innovations in livestock systems in Africa. INRA Animal Productions 27 (2): 161-174.

Zida D, Bognounou F, Sanou L, Savadogo P, Koala J, Sawadogo L. 2023. Transplanted seedling age and watering effects on the field performance of *Senegalia macrostachya* (Rchb. ex DC.) Kyal. & Boatwr., a high-valued indigenous fruit tree species in Burkina Faso. Trees, Forest and People 14:100461. doi: 10.1016/j.tfp.2023.100461