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RECEIVED 12 November 2024

ACCEPTED 27 January 2025

PUBLISHED 07 February 2025

## CITATION

Ilboudo B, Zaré A, Traoré ICE, Bondé L,  
Guuroh RT and Ouédraogo O (2025) Pastoral  
livestock farming constraints and adaptation  
strategies in response to institutional reforms  
in the Sudano-Sahelian zone of West Africa.  
*Front. Sustain. Food Syst.* 9:1526582.  
doi: 10.3389/fsufs.2025.1526582

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# Pastoral livestock farming constraints and adaptation strategies in response to institutional reforms in the Sudano-Sahelian zone of West Africa

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**Introduction:** Livestock farming is one of the main socio-economic activities in West Africa, predominantly extensive and reliant on natural rangelands. In Burkina Faso, the pastoral zone creation process began in 1980 to sedentarize livestock farmers, reduce social conflict, and strengthen livestock production. Therefore, these areas were subjected to institutional reforms with direct consequences on pastoralism. This study aimed to analyze the effects of land tenure and protected area governance reforms on the pastoral production system by identifying concomitantly related constraints and adaptation strategies adopted by local communities.

**Methods:** Data were collected through analysis of policy documents, and surveys from 280 key informants and household heads related to the pastoral zone of Yallé using individual interviews and focus group discussions. The main information collected included pastoral landscape and the current state of the livestock production system. Data were also taken on pastoral constraints related to land reforms, protected area governance, and alternative adaptation strategies developed to address constraints.

**Results and discussion:** The changes highlighted are the challenge to the pastoral zone and the appropriation of pastureland by other users inducing range shrinkage, inaccessibility to water resources, and farmer-herders conflicts. In response, some livestock farmers drive their herds out of the country, while others illegally graze in protected areas. They also combine socio-professional conversion to support their livelihoods, with atypical transhumance in the rainy season and seek herd feed satisfaction. New forage harvesting techniques, supported by training, and the integration of agriculture into livestock farming are opportunities to promote agropastoralism, more sustainable. Policymakers should ensure that livestock development actions are legally secure and that institutional reforms promote common resource use in pastoral areas. Also, livestock farmers are encouraged to create community structures for coordinated resource management and conflict resolution. Further, State institutions must supervise investor establishment in pastoral zones while preventing private property rights over the land.

## KEYWORDS

agropastoralism, atypical transhumance, pastoral zone, range shrinkage, Yallé

## Introduction

Livestock farming ensures many families' food and financial security and constitutes a socio-cultural identity for some social groups (Alary et al., 2011). It provides multiple services such as animal traction, field fertilization, and transportation. In West Africa, livestock production is dominated by pastoral, nomadic, and transhumant farming systems, which are highly beneficial to the environment and local communities (Timpong-Jones et al., 2023). Pastoralism is one of the earliest forms of livestock production, which followed the domestication of animals (Scanes, 2018). This system relies on natural rangelands and surface waters, which provide the bulk of the herd's feed, making pastoralism dependent on natural resources (Wu et al., 2023). However, these resources are in decline due to the combined effects of climatic change and human pressure (Linus and Pudensiana, 2014; Jones et al., 2018; Weiskopf et al., 2020). The drought crises of 1970 to 1980 forced people to move from the Sahel to Southern zones in search of better resources, marking the expansion of pastoral livestock farming to southern regions (Boutrais, 2009; Robert, 2010). As these new Sudano-Sahelian territories are essentially agricultural areas with protected areas, the organization of the livestock sector has become a necessary condition for cohabitation with agriculture. In Burkina Faso, the Pastoral Zones (PZ) process began in the 1980s, with the identification of some sites, their development, and the installation of essential infrastructure for livestock activities (Ouoba-Ima, 2018). The main goals of these PZ were to reduce social conflicts by settling livestock farmers, and strengthening their resilience with livestock integration into agriculture to improve animal production (Robert, 2010). During PZ creation in the 1980s, access to land was strictly determined by the Government which managed land at a national scale according to land regulation policy. However, in 1996, a new land policy was adopted, by assigning land management responsibility to local communities (Gniza, 2021). This involvement of the local communities in land management is an application of customary law to land management. This land tenure system is often seen as better for farming communities because of its social role, compared with private property ownership rights, which seem to be disadvantageous, particularly for the poor (Bainville, 2017). Reforms in protected areas governance characterized this same period and focused on conceding the management of conservation spaces to the private sector for the exploitation of wildlife resources (Bouché et al., 2011; Sawadogo, 2011). These management changes involve natural resources and grazing land on which pastoralism relies (McKune et al., 2015). Research tends to show the impact of

political resource management systems on extensive livestock production in some regions of the world. In Mongolia, land use policy changes have been identified as one of the most decisive factors in livestock structure modification (Jiang et al., 2019). In Algeria, land tenure policies that have promoted land appropriation and investments, as well as the sedentarisation of livestock farmers, have led to the fragmentation of steppe areas and affected livestock farming systems (Youcefi and Marouf, 2023). Over the past two decades, many studies have been conducted in West Africa on the changes affecting pastoral livestock farming. Most of them are concerned about climate change which is a source of diminishing food resources for livestock. The adaptation strategies developed include finding feed supplements for the animals, integrating cropping with livestock farming, mobility, herd destocking, and livestock diversification (Zampaligré et al., 2014; Kima et al., 2015; Nougbara et al., 2021; Idrissou et al., 2023). The land tenure constraints encountered are often associated with herd health problems. The strategies used in these cases include vaccination combined with depressurization, herd mobility, use of crop residues, herd feed supplementation, and illegal grazing in protected areas (Kiéma and Fournier, 2007; Koutou et al., 2016b; Zongo et al., 2017). In West Africa's cotton belt, 'sedentarisation' of transhumant pastoralists policies has weakened farmers' livelihoods and led to a decline in soil fertility (Dossouhoui et al., 2023). It appears that the interactions of institutional actions with pastoralism in its new configuration are poorly examined. The combined effects of reforms related to land tenure and protected area governance on pastoral livestock farming have not been studied. However, the analysis of livestock farming system dynamics requires the consideration of a wide range of factors that can influence practices and livelihoods. Social factors such as cultural and spiritual values interfere with political elements and have a proven influence on farming systems (Pérez-Lombardini et al., 2024). The livestock sector is influenced by political action because it is dependent on land use tenure (Zhang et al., 2017). In addition, the proximity of pastoral livestock farming to conservation areas, in addition to farmland, establishes interactions with the management of protected areas. In the context of increasing demand for animal products due to population growth (FAO, 2019), a deep diagnostic of pastoralism under institutional reforms is highly needed to cope with challenges in livestock productivity and sustainable management of natural resources.

The objectives of this study were to (i) describe pastoral constraints related to institutional reforms and, (ii) analyze the adaptation strategies developed by local communities in response to these constraints.

Three main questions will be addressed in this research:

- (i) How do land tenure and protected area governance reforms affect the pastoral production systems in the Sudano-Sahelian zone?
- (ii) What strategies are implemented by local communities to mitigate the impacts of institutional changes on pastoral livestock farming systems?
- (iii) What demographic and socio-professional factors drive the adaptation strategies adopted by local communities?

Abbreviations: CA, Correspondence analysis; CF, Classified Forest; HCA, Hierarchical cluster analysis; HCPC, Hierarchical clustering on principal components; PCA, Principal component analysis; PZ, Pastoral zone; USD, United States dollar.

## Materials and methods

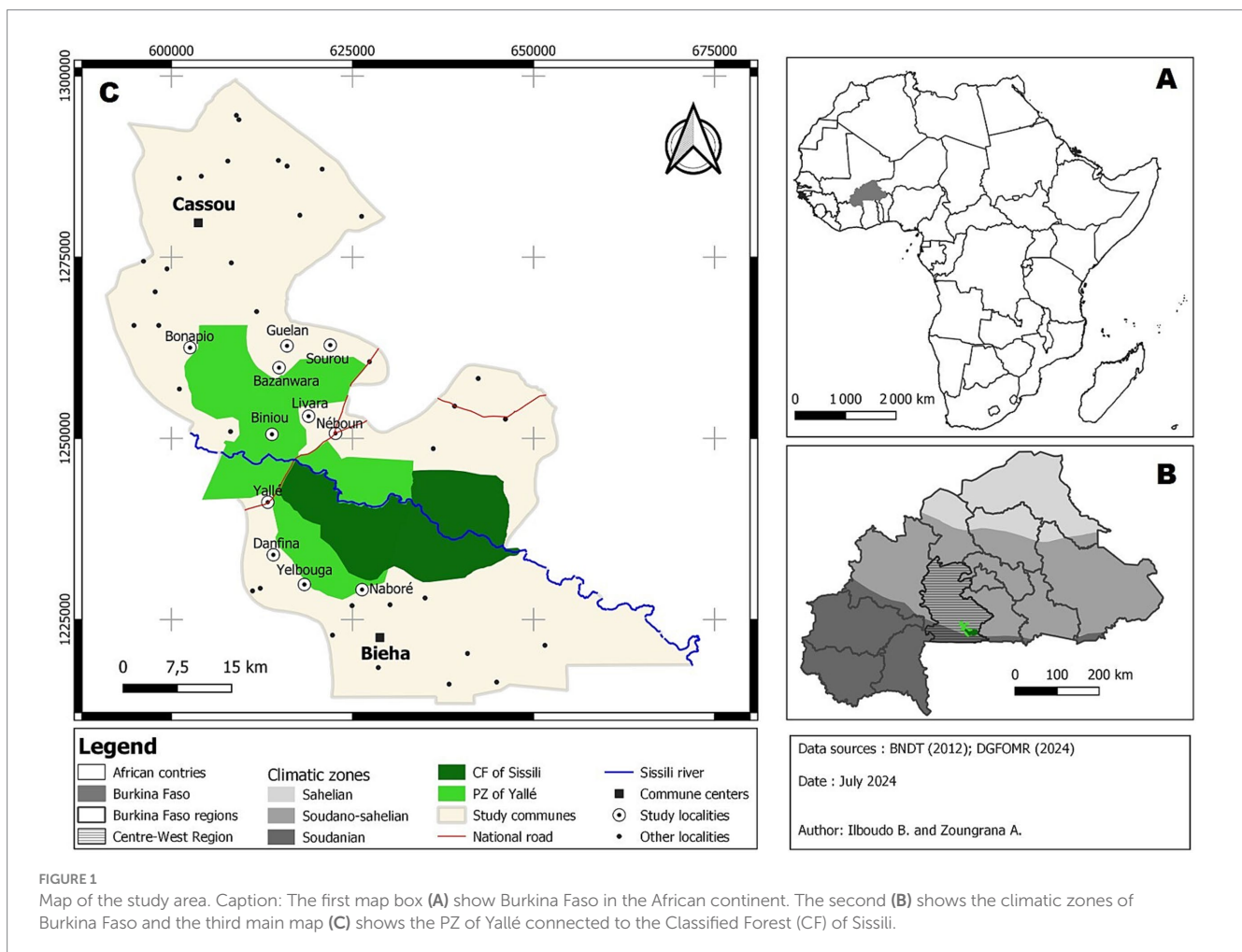
### Study area

This study was conducted in PZ of Yallé, one of 26 PZ of Burkina Faso, located in the South of the Sudano-Sahelian climatic zone (Figure 1). This part of the country receives migrants from the north and is particularly affected by land sales, driven by landowner management tenure (Birba, 2020). The PZ was delimited to over 40,000 hectares, equipped with herd tracks and firebreaks, and subdivided into Pastoral Units, with sanitary and hydraulic pastoral infrastructures. It is adjacent to the Classified Forest (CF) of Sissili with an area of 32,700 hectares, designated as a hunting zone. The PZ is traversed by National Road 6, which links the capital city, Ouagadougou to Léo, the capital town of the Sissili province. The main river is the Sissili, which flows through the PZ from North-West to South-East. Over the past 30 years (1994–2023), the average annual rainfall is  $915.98 \pm 134.21$  mm and the average daily temperature varied from 22.18 to 35.59°C, (National Meteorology Agency of Burkina Faso climate data, 2024). Hydromorphic soils are dominant, corresponding to the WRB geysols group (Thiombiano and Kampmann, 2010). The vegetation is characterized by shrubby and wooded savannahs. The woody stratum is distinguished by *Detarium microcarpum* Guill. & Perr., *Khaya senegalensis* (Desv.) A.Juss.,

*Daniellia oliveri* (Rolfe) Hutch. & Dalziel, *Terminalia leiocarpa* (DC.) Baill., *Combretum glutinosum* Perr. ex DC., and *Vitellaria paradoxa* C.F.Gaertn. The herbaceous is dominated by *Andropogon pseudapricus* Stapf, *Cenchrus pedicellatus* (Trin.) Morrone, *Andropogon gayanus* Kunth, *Hyparrhenia subplumosa* Stapf, and *Hyparrhenia smithiana* (Hook.f.) Stapf (Nacoulma et al., 2018). The dominant ethnic groups in the study area are Nounis (who are native landowners) and migrant groups such as the Fulani and the Moosse. The main socio-economic activities, in order of importance are agriculture and livestock farming. Land control is the responsibility of land chiefs, assisted by village chiefs, and access to land is by inheritance, gift, or purchase. Some pastoralists were established in the PZ before its creation but others have been installed there by the State authorities.

### Data collection

Data collection for this study involved two key aspects: review/analysis of policy documents, and field data using various complementary social science approaches. The policy documents analyzed include the land tenure reforms of 1984 and 1996, the PZ creation decree of 1989, and the concession agreement for the classified forest of Sissili of 1996. Field data were collected using the participatory rural appraisal (PRA) approach, in two complementary



steps from June 2022 to May 2023 to capture the particularities of each season throughout the year. The participatory rural appraisal emphasizes the active involvement of local communities in assessing their conditions and needs with the advantage of arousing great interest and strong support (Basupi et al., 2019). The first step was qualitative, followed by the second step which was quantitative.

### Qualitative step

This step was performed using individual interviews with key informants, focus group discussions, and field observations (Ouédraogo et al., 2021). Interviews with key informants included heads and personnel of the environment and livestock sector, staff of municipalities and livestock development partners in the study localities, landowners, and farmers involved in pastoral livestock

farming (Table 1). The aim was to assess changes in the pastoral landscape and land management in response to the targeted institutional reforms. The implications of these changes for pastoral livestock farmers and their activities were also researched. Two focus group discussions, each comprising 8 to 10 household heads were organized using a semi-structured guide to improve and consolidate the findings of the individual interviews. The 2 most remote villages in the PZ were selected with a group composition representative of the diversity of the respondents. Field observations were also carried out in croplands and fallow areas of the PZ, and in protected areas (CF of Sissili). The state of the grazing areas and pastoral practices were observed in the field and noted according to the specific periods of the pastoral calendar concerned. This stage attempted to design a semi-structured questionnaire, which was tested with 13 pastoral livestock farmers. The final questionnaire was administered during the second phase of data collection.

TABLE 1 Overview of interview participants in the study.

Interview style	Numbers	Participants numbers
Key informant individual interviews	20	20
Focus group discussion by using a guide	02	18 (8 + 10)
Semi-structured individual interviews	242	242
Total of participants	280	
Interview participants' characteristics		
Chief Veterinary of Pastoral Zone	01	01
Chiefs' forestry in study municipalities	02	02
Director of Environment, Water and Sanitation Ministry	01	01
Director of Agricultural, Animal Resources and Fisheries Ministry	02	02
Study municipalities staff	02	02
Staff of livestock development partners	02	02
Chiefs, assistant chiefs, and village elders who are landowners	04	04
Pastoralist resource persons	06	06
Household heads involved in pastoral livestock farming	262	262
Total of participants	280	

### Quantitative step

Using purposive sampling, 242 household heads involved in pastoral livestock farming, were surveyed in eleven (11) riparian villages of the PZ of Yallé (Figure 1). This approach made it possible to consider the diversity of the sample composition and existing situations. Data collected with a semi-structured survey included age, ethnicity, distance from the protected area, education level, land tenure, number of cattle, and farm size. Each respondent was asked to rank, their livestock framing constraints resulting from the targeted institutional reforms in decreasing order of importance. They were also invited to indicate which of the main identified adaptation strategies had been adopted in response to the constraints. Respondents were allowed to express their ideas, knowledge, and feelings about each question. This approach is particularly appreciated by the participants, who feel satisfied to be listened to.

### Data processing and analysis

#### Qualitative data

Data from individual interviews and focus group discussions were transcribed into MS Word files and subjected to thematic content analysis to describe the main changes in the pastoral landscape and land management, due to institutional reforms, and their implications on livestock farming. The main adaptation strategies developed in the face of changes have been highlighted in the descriptions. These data were also used to describe the full annual pastoral calendar in the study area and to identify vulnerable seasons in which constraints frequently occur. Qualitative data were also used to triangulate and interpret the survey data (Zoma-Traoré et al., 2020).

#### Quantitative data

A weight has been assigned to each pastoral constraint so that the first constraint has the highest score. The constraints mentioned in the first order have been represented graphically by a circular diagram. A Principal Component Analysis (PCA) using “FactoMineR” package has been applied to the constraint data matrix to describe their relationships. The citation frequencies (FR) for each adaptation strategy were calculated using Equation 1:



$$FR = \frac{n_s}{n} * 100 \tag{1}$$

$n_s$  is the number of respondents who chose adaptation strategy  $s$ , and  $n$  is the total number of respondents. The Fulani ethnic group represented a larger proportion of the respondents. They are also called pastoralists, and therefore practice pastoral livestock farming more than the other ethnic groups. Based on the data collected, Correspondence Analysis (CA) using FactoMineR package was performed to explore the relationship between adaptation strategies and in addition with demographic and socio-professional traits. To this end, contingency tables of the relative frequencies were developed using both factors: demographic trait with 3 modalities (age category, ethnic group, distance from protected area) and socio-professional profile with 3 modalities (education level, land tenure, farmers typologies). Only modalities and adaptation strategies with good contributions to axis formation and good representation quality on the axis were interpreted on the CA plot. The demographic and socio-professional trait was structured as follows (Table 2):

-Age category: three age categories were defined in this study (Assogbadjo et al., 2008): young (under or equal to 30 year olds), adult (31 to 60 year olds), and old (upper than 60 year olds);

-Ethnic groups: ethnicity of respondents was focused on the four main ethnic groups in the study area (Nouni, Moosse, Silmi-Moose, and Fulani);

-Education level: respondents were ranged in four education categories (illiterate, literate in the local language, primary school, and secondary school);

-Land access: Land access referred to heritage, donation, purchase, rent, or attribution for pastoralists settled by the State in the PZ;

-Typology: three farmers' typologies were developed, based on the typology of Vall et al. (2006), adapted to our context. Pastoralists settled in the PZ were advised to limit the size of their farms to between 2 to 3 hectares maximum. Thus, producers with fewer than 10 cattle are considered to be farmers, those with at least 10 cattle and farming more than 3 hectares are agropastoralists, and pastoralists have at least 10 cattle and do not cultivate more than 3 hectares;

-Distance from the protected area: study localities were classified into three categories distance from the protected area, CF of Sissili proximate: distance less than 5 km; distant: between 5 and 10 km, and remote: more than 10 km from the protected area.

The typology of livestock production systems was established using Hierarchical Clustering on Principal Components (HCPC) to classify the respondents according to the main pastoral constraints and adaptation strategies (Alvarez et al., 2018). It also enabled the identification of the correspondence between pastoral constraints and the adaptation strategies adopted. Two (02) pastoral adaptation strategies (herd feed supplementation and diversification of herd composition), adopted by almost all respondents, therefore with low variability, were not considered. The PCA was performed to reduce the dataset into the first principal components. This was followed by hierarchical cluster analysis (HCA) on the dataset of 13 variables (Table 3) using Ward's minimum-variance method to highlight clusters and their description (Ward, 1963). The Vtest values for both constraints and adaptation strategies are used to characterize each cluster. The first constraints and adaptation strategies were considered as the characteristics of each cluster. The analysis and visualization were performed using the FactoMineR, factoextra, and Factoshiny packages. All the multivariate analyses were performed using R software version 4.3.1 (R Core Team, 2022).

TABLE 2 Demographic and socio-professional characteristics of respondents.

	Factors	Modalities	Frequencies
Demographic characteristics	Age category	Young	9.50%
		Adult	72.73%
		Old	17.77%
	Ethnic group	Fulani	78.93%
		Moosse	9.50%
		Silmi-moose	3.31%
		Nouni	8.26%
	Distance from protected area	Proximate	30.13%
		Distant	22.31%
Remote		47.52%	
Socio-professional characteristics	Education level	Illiterate	78.51%
		Local language	13.64%
		Primary	5.79%
		Secondary	2.07%
	Land tenure	Attribution	17.77%
		Heritage	35.54%
		Donation	40.50%
		Purchase	2.48%
		Rent	3.72%
	Farmers typology	Farmers	14.46%
		Agropastoralists	33.47%
Pastoralists		52.07%	

## Results

### Changes in land management and pastoral landscape

The findings of the study show that herders have been evicted from some parts of PZ of Yallé. In the other parts, the lands have been sold off to agribusinessmen by native landowners, or subjected to farm expansion (Table 4). The information reveals that some sections of the CF of Sissili were used to create PZ, but the legal formalization of the process has not been completed, therefore, the status of the PZ of Yallé and its boundaries are controversial.

### Pastoral constraints resulting from institutional reforms

The most commonly cited constraints faced by pastoral livestock farming include the reduction of rangeland areas (50%), the occupation of water sources for herds to drink (25.45%), and the obstruction of movement tracks or corridors (21.49%) used by herds

TABLE 3 Overall pastoral constraints due to institutional reforms and adaptation strategies developed to cope with them.

Code used	Explanation	Constraints or strategies	Using for HCA analysis
range_shrinkage	Reduction of rangeland areas	Constraint	Yes
watering_occupation	Occupation of the water sources for herds to drink	Constraint	Yes
track_obstruction	Obstruction of movement tracks or corridors used by herds	Constraint	Yes
fodder_reduction	Reduction in the availability or quality of fodder for livestock	Constraint	Yes
conflict	Conflicts between herders and farmers	Constraint	Yes
roadhouse	Grazing along roadsides and around houses	Strategy	Yes
haymak	Haymaking, that consists of mowing grass to dry it for feeding the herd	Strategy	Yes
transh	Transhumance, seasonal movement of livestock within or outside the country	Strategy	Yes
livelidivers	Livelihood diversification by combining several activities and extending farmland	Strategy	Yes
fatte	Fattening cattle or sheep for sale	Strategy	Yes
glean	Gleaning, refers to the grazing of crop residues after harvesting	Strategy	Yes
grazpa	Fraudulent herd grazing inside the protected area	Strategy	Yes
livestmigr	Migration of livestock to another country	Strategy	Yes
herddivers	Diversification of herd composition by combining cattle with small ruminants	Strategy	No
feedsuppl	Herd feed supplementation	Strategy	No

TABLE 4 Effect of institutional reforms on land management and pastoral landscapes.

Changes in pastoral landscapes and land management	Reforms concerned
The herders have been evicted from some parts of the pastoral zone	Concession agreement
The pastoral zone lands where herders were evicted have been attached to the classified forest to rehabilitate its boundaries	Concession agreement
There is illegal grazing in the classified forest, especially in the rehabilitated parts, despite the payment of fines for offenses of up to \$1,327.52 (USD)	land tenure reform
Several hundred hectares of land have been sold in the pastoral zone to agribusinessmen, who often fence, farm, or rent the land for between \$33.04 (USD) and \$49.56 (USD) per hectare	Concession agreement, land tenure reform
There is farmland expansion in the PZ, and damage caused by herds in the fields leads to conflict and often to the payment of fines of up to \$580.29 (USD)	Concession agreement, land tenure reform
Livestock sector partners are reticent to invest in the PZ and the number of cattle has fallen, for example: from 12,000 heads in 2016 to 4,000 heads in 2023	Concession agreement, land tenure reform

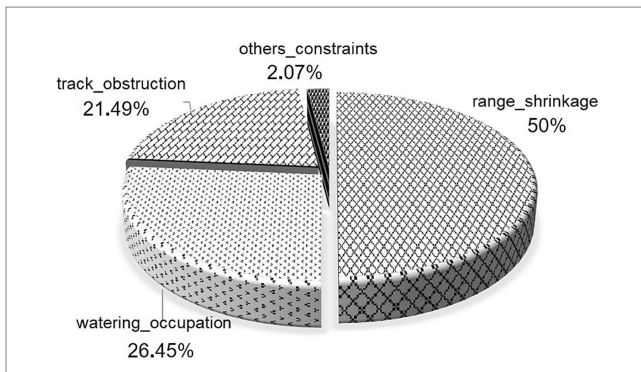
(Figure 2). These constraints are particularly acute during the rainy season (from mid-May to mid-November).

### Interconnections between pastoral constraints

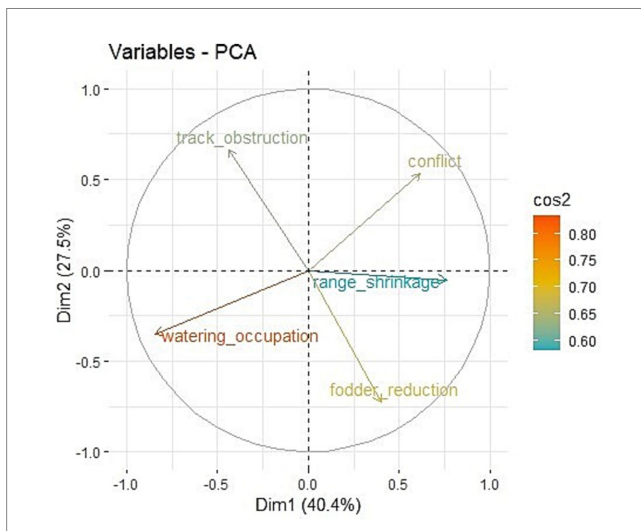
The first two axes of the principal components analysis (PCA) explained 67.9% of the constraint's distribution (Figure 3). The Pearson correlation between constraints and PCA principals' components revealed that rangeland area reduction and herds track obstruction are both associated with farmer-herder conflicts (Table 5). Institutional reforms have deeply disrupted pastoralism and favored conflicts between farmers and herders.

### Adaptation strategies of pastoral livestock farmers to institutional reforms constraints

Most respondents (99.17%) diversify their herd composition by combining cattle with sheep and goats. The average number in a herd of cattle is around  $27.68 \pm 18.52$  heads per household and with regard to small ruminants, an average flock is made of  $21.40 \pm 13.72$  heads of sheep, and  $18.36 \pm 11.68$  heads of goats. During the hunger gap in the hot dry season (from March to mid-May), 90.08% supplement the feed for their herds with crop residues, cut grass, woody fodder, and agro-industrial by-products. They prioritize weakened animals, work cattle, young animals, and milking cows by selecting them for feeding. In the cold dry season (from mid-November to end-February), 77.68% of respondents graze their herds on crop residues. In the rainy and hot dry seasons, some practice transhumance (34.29%) or illegally



**FIGURE 2**  
Main pastoral constraints due to institutional reforms. Caption: range\_shrinkage: reduction of rangeland areas; watering\_occupation: occupation of the source of water where the herd comes to drink; track\_obstruction: obstruction of movement tracks or corridors used by herds.



**FIGURE 3**  
Factor map of PCA, showing relationships between pastoral constraints. Caption: range\_shrinkage: reduction of rangeland areas; watering\_occupation: occupation of the sources of water where the herd comes to drink; track\_obstruction: obstruction of movement tracks or corridors used by herds; fodder\_reduction: reduction in the availability or quality of fodder for livestock; conflict: Conflicts between herders and farmers.

**TABLE 5** Correlation between constraints and PCA principals' components.

	Dim.1	Dim.2	Dim.3	Dim.4	Dim.5
Range_shrinkage	<b>0.76</b>	-0.05	0.11	0.64	0.04
Watering_occupation	-0.84	-0.35	-0.37	0.15	0.08
Track_obstruction	-0.44	<b>0.66</b>	0.60	-0.04	0.05
Fodder_reduction	0.40	-0.73	0.38	-0.40	0.05
Conflict	<b>0.62</b>	<b>0.53</b>	-0.47	-0.34	0.05

The Pearson correlation coefficients are in bold on a given dimension when the corresponding pastoral constraints are significantly correlated to this dimension.

exploit the classified forest (56.61%). Departure to cross-border transhumance starts at the beginning of the rainy season (mid-May to June), and herds return starting in mid-November to take advantage of crop residues. The rainy season is also characterized by grazing on roadsides and around concessions (43.39%) and haymaking (50%). Among respondents, 52.89% fatten cattle or sheep before selling, 26.44% have their herd permanently sent to a neighboring country, and 28.51% diversify their livelihood and farming system (Figure 4).

### Relationship between adaptation strategies and demographic and socio-professional factors

The factor maps of CA, show the relationships between pastoral adaptation strategies and demographic factors (Figure 5).

Pastoral livestock farmers practicing fattening, also engage in transhumance and graze along roadsides and around houses, but the age category does not determine specific adaptation strategies (Figure 5A). Livelihood diversification, is combined with grazing along roadsides and around dwellings, transhumance, gleanings, and livestock migration however, their adoption is not related to the distance from the classified forest (Figure 5C).

Axis 1 and 2 in Figure 5B explain 94.64% of the total point variation. The Fulani are characterized by livelihood diversification, transhumance, and livestock migration. The Nouni are distinguished by herds diversification and haymaking, while the Silmi-moose are characterized by fattening.

The factor maps of CA, show the relationships between pastoral adaptation strategies and socio-professional traits (Figure 6).

Axis 1 and 2 in Figure 6A explain 93.99% of the total point variation. Livestock migration, grazing in the protected area, and haymaking are adaptation strategies associated with local language.

Axis 1 and 2 in Figure 6B explain 93.04% of the total point variation. Respondents settled by the State in the PZ are distinguished by the transhumance and haymaking. Those who rent land are characterized by fattening, and grazing along roadsides and around houses is typical of those who have purchased land to establish themselves.

Axis 1 and 2 in Figure 6C explain 100% of the total point variation. Livelihood diversification is associated with transhumance and livestock migration.

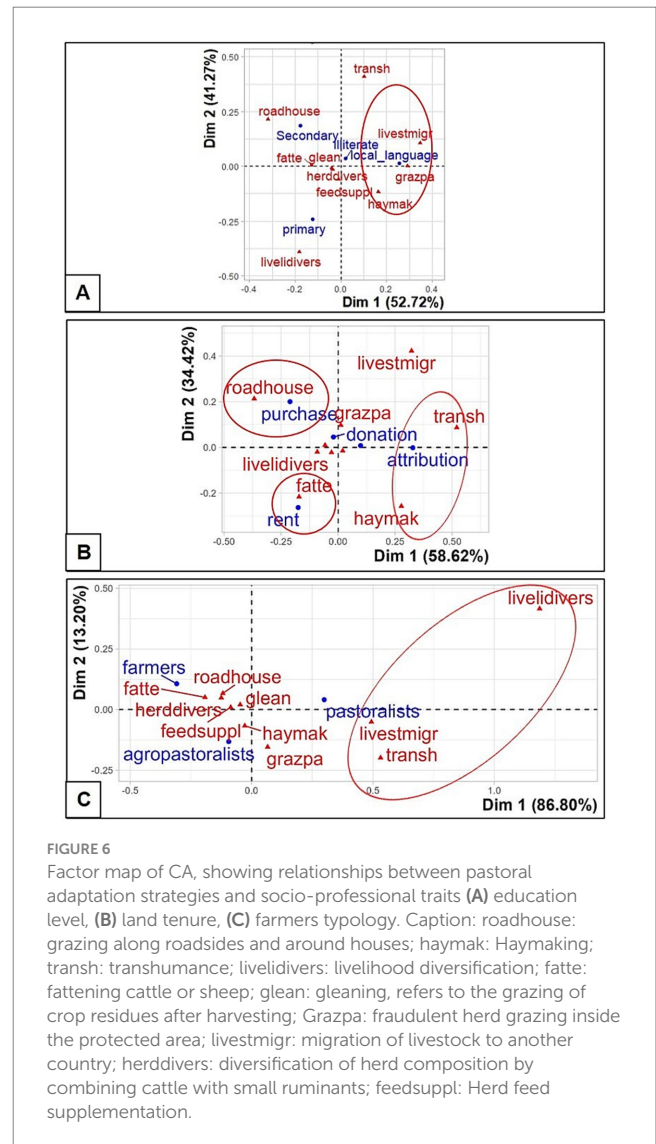
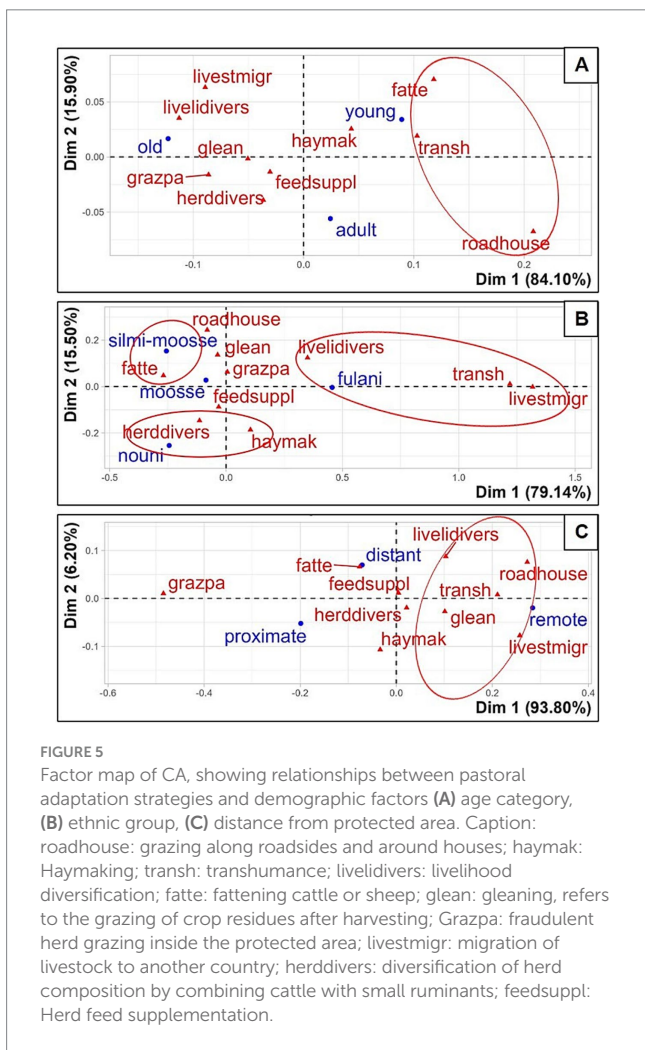
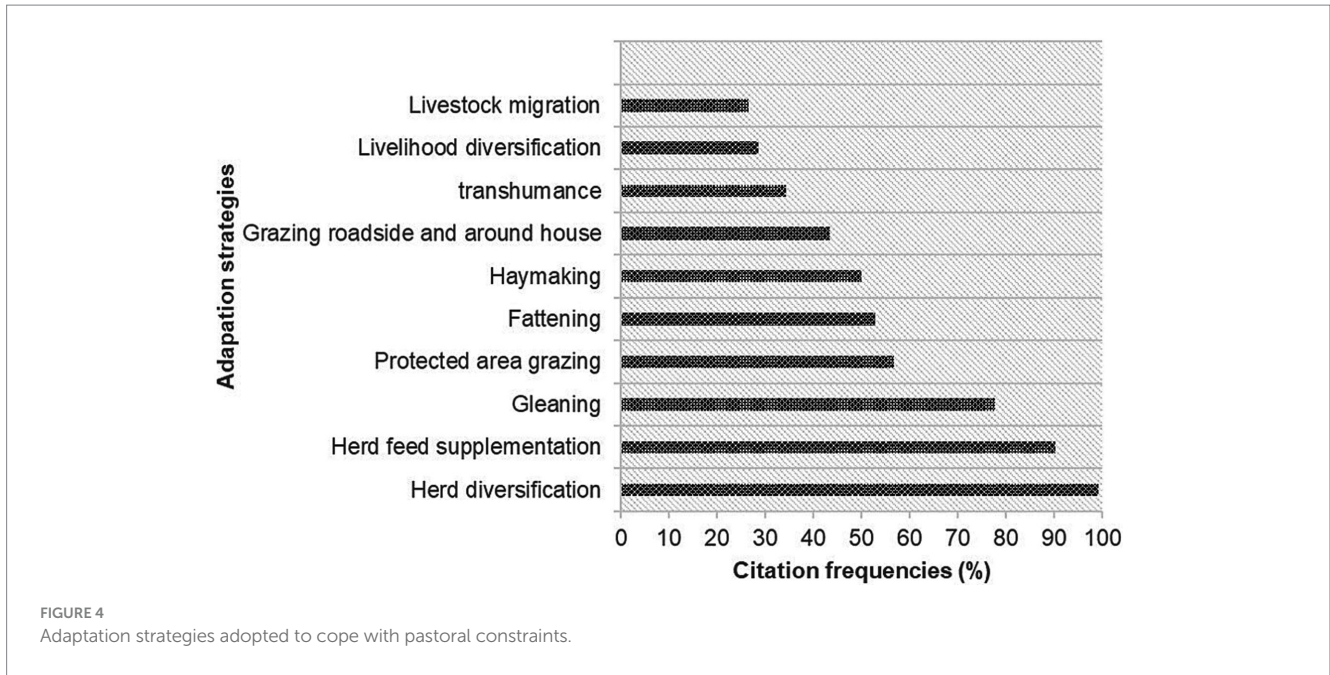
For pastoral livestock farming, several adaptation strategies are combined to face constraints, however, ethnicity, local language literacy, and land tenure drive some of them.

### Typologies of pastoral livestock farmers shaped by adaptation strategies to face constraints

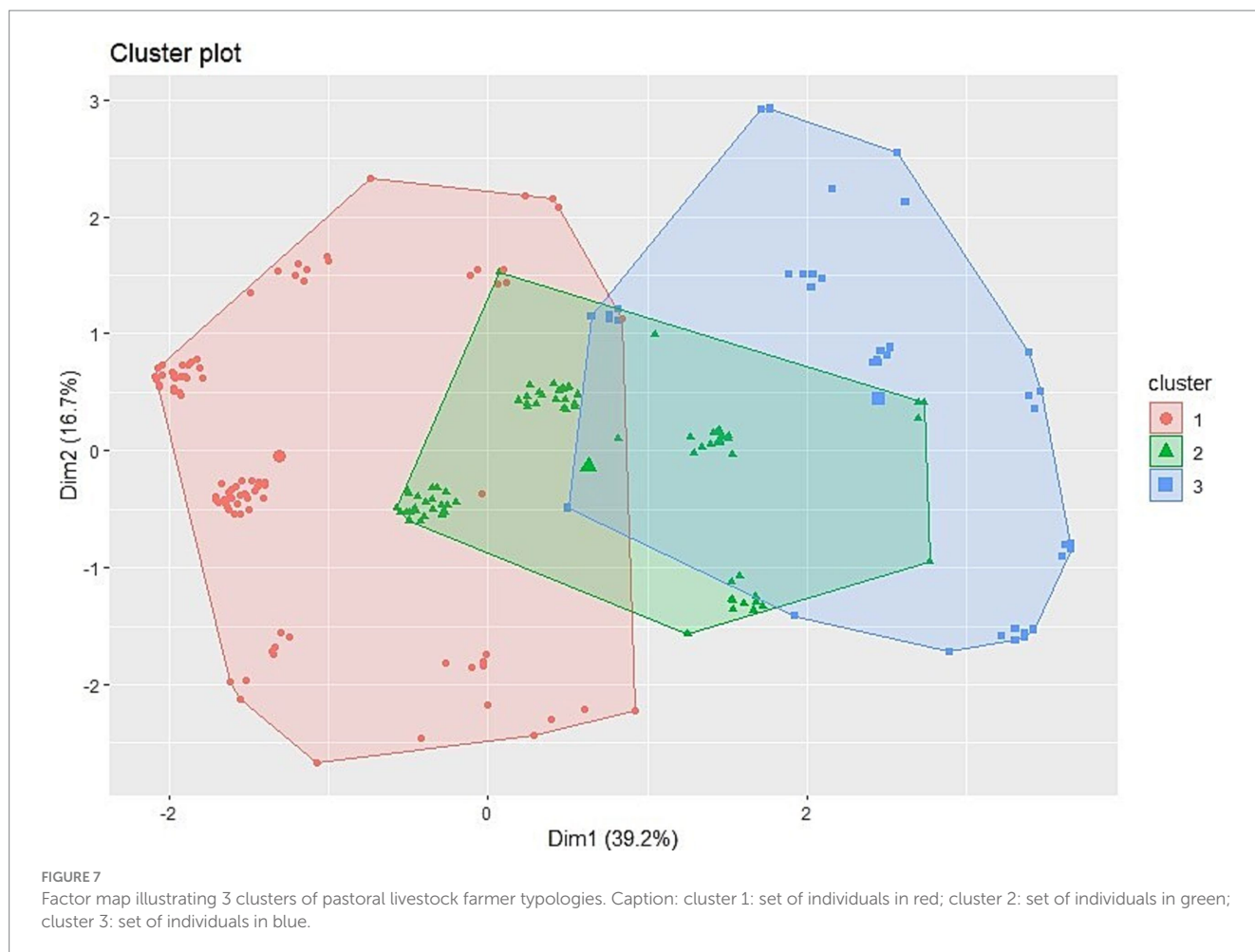
The first 2 principal components of the factor map on pastoral livestock farmers's typologies explained 55.9% of the variability in the dataset (Figure 7).

Each cluster is characterized by the most expressed pastoral constraints and dominant adaptation strategies, but all clusters share some common traits.

Cluster 1 includes pastoral livestock farmers expressing the occupation of the watering place where the herd comes to drink as a







major pastoral constraint (v.test =11.85; p-value = 1.95E-32). The livestock migration to another country is their principal adaptation strategy (v.test =2.20; p-value = 2.71E-2). They are primarily older heads of families who have sedentarized in the PZ, but send most of their herd, in the care of their children, to neighboring Ghana. Most of them have already been victims of evictions carried out in some units of the PZ. They have fewer livestock in the PZ and have turned to agricultural exploitation or other activities to secure their livelihoods.

Cluster 2 comprises the respondents who mentioned rangeland area reduction as the most important pastoral constraint (v.test =9.53; p-value = 1.47E-21). They use illegal grazing inside the protected area as an adaptation strategy (v.test =3.00; p-value = 2.62E-3). These livestock farmers are found in parts of the PZ which are mostly occupied by agribusinessmen. They have large herds and are keen to keep their herds in the PZ. Cluster 3 is made up of respondents who feel that the conflicts between herders and farmers constitute the main pastoral constraint (v.test =14.14; p-value = 2.11E-45). The illegal grazing in the protected area is their dominant adaptation strategy (v.test =5.60; p-value = 2.08E-8). This cluster represents livestock farmers, with relatively large herds, who are settled in parts of the PZ that is characterized by the expansion of farms.

## Discussion

### Disruption of pastoral livestock farming due to institutional reforms

Institutional reforms raised controversy in pastoralism. The decision to grant a concession for the CF of Sissili repealed the decree creating the PZ. Part of the classified forest was used to develop the PZ. However, the process does not seem to be fully formalized. The classified forest was recovered to re-establish its former boundaries. The herders installed in this part were evicted and had difficulty resettling in other units in the PZ. Previous studies found that resettlement decreased the total livestock population, average herd size per household, and daily milk production (Gai et al., 2022).

In addition, a large scale of land has been sold to agribusinessmen in the PZ. The land tenure reforms of 1996 assigned the land management of the landowners and local communities (Gniza, 2021). The same period was characterized by policies encouraging people to invest in the land. Repealing the text of the PZ called into question his situation. This fact has favored farmland expansion and abundant land acquirement with easy access across National Road 6. The agribusinessmen, new landowners with large-scale investments are

reluctant to share their properties with local communities. Agribusinessmen take over vast areas of land in the PZ, depriving livestock farmers of access to pasture, water resources, and livestock health infrastructures. This leads to a loss of income for pastoral livestock farming and affects the livestock farmers' livelihoods. These details reveal a phenomenon of land grabbing in the PZ by agribusinessmen, as mentioned by Davis et al. (2014). This land grabbing phenomenon seems to be a consequence of land management by the customary system. It appears that customary law has paved the way for the marginalization of rural populations in terms of access to common land, as indicated by Bainville (2017). Bekele et al. (2021) and Bekele et al. (2022), have shown that investments on land properties are a source of conflicts and scarcity of grazing land. Also, State action could change the grazing system and threaten pastoral territories (Akall, 2021). For this reason, according to the FAO (2023), the success of the livestock sector is linked to political dispositions. With changes resulting from institutional reforms, the PZ is characterized by rangeland reduction, herd water resources occupation, and cattle track obstruction. The Herders installed in the PZ of Yallé, were allowed to cultivate no more than 3 hectares to feed their families. Yet, with farmland expansion, most pastureland is converted into vast expanses of cereal, *Sesamum indicum* L., *Glycine max* (L.) Merr. and *Gossypium hirsutum* L. fields in the rainy season. In some cases, the land sold is a cattle track, a rangeland, or a watering point where the herd used to drink. Crop residues from farms located on lands owned by agribusinessmen are less accessible to herds than crop residues from family farms. The pastoral vocation of an area should be reflected in the development of pastoral activities. However pastoral livestock farming resources are declining. During the rainy season until harvest time, the herd's attempts to graze the small reserves of rangeland or to access watering points or vaccination parks involve a high risk of damage to the crop fields. Some conflicts resulting from herd damage in the fields are resolved by agreement between the herd owner and the field owner. Mostly, the damage is punished by fines, which does not always meet a unanimous agreement between the actors. Farmer-herders conflicts are highly complex, multi-factorial, and likely to become increasingly violent with land shrinkage (Sawadogo et al., 2024). These kinds of conflicts and fines for field damage are also reported in the cotton-producing zone in Western Burkina Faso (Koutou et al., 2016a).

## Adaptation of pastoral livestock systems to the institutional reforms impacts

Pastoral livestock farming is dominated by herd diversification, in the PZ of Yallé. With limited rangelands, livestock farmers combine cattle with small ruminants like sheep and goats. This allows the optimum use of degraded pastures. The small ruminants among the herds reflect a coping strategy used by livestock farmers to deal with the risk factors associated with institutional reforms. Multi-species livestock farming strengthens the resilience of households to the degradation of pastoral resources and other environmental/ climatic challenges (Megersa et al., 2014). Cattle have a feeding preference for grasses, sheep combine grasses and woody leaves, and goats have a diet based on woody leaves (César, 2005). Therefore, small ruminants can graze on rangelands rejected by cattle. Livestock diversification is a means of improving household well-being in the face of climate risks

and multiple shocks (Ngigi et al., 2021). Livestock diversification is also mentioned as an adaptation strategy to mitigate the risks associated with animal feed sources in pastoral livestock farming in conflict situations (Fadare et al., 2024).

Herd feed supplementation in the hot dry season is also widely adopted by pastoral livestock farmers. They explain that the herd wasn't fed enough during the rainy season to store body reserves. As a result, they lose a lot of weight during the dry season, which is a hunger season. Some animals are so weakened that they need feed supplements to stand. Feed supplements involve mown grasses, crop residues, agro-industrial by-products, and leaves of woody plants. The grass species commonly used as feed supplements are *Cenchrus pedicellatus* (Trin.) Morrone, *Rottboellia cochinchinensis* (Lour.) Clayton, *Andropogon pseudapricus* Stapf, and the woody plants include *Azelia Africana* Sm. ex Pers., *Pterocarpus erinaceus* Poir., *Stereospermum kunthianum* Cham. and *Khaya senegalensis* (Desr.) A.Juss. In the Sahelian region of Burkina Faso, herders also use mown grasses, crop residues, and woody fodder in response to the scarcity of fodder (Ouédraogo et al., 2021). The Woody plants used for animal feed are often overexploited, threatening their conservation (Hien et al., 2021). Due to climate change, haymaking, and concentrated livestock feed are also used as strategies (Kima et al., 2015).

In practice, adaptation strategies are combined to address pastoral constraints. This could be explained by the ineffectiveness of a single adaptation strategy face to several constraints. Employing several strategies allows them to benefit from their combined results and optimize their advantages. The use of various adaptation strategies could also be justified by the severity of pastoral constraints following institutional reforms. Pastoralists have several ways of adapting, reflecting their flexibility (Korbéogo, 2014; Korbéogo, 2016; Kima et al., 2015; Abdou et al., 2020;). Knowledge and integration of adaptation strategies into development programs can counter the negative effects of reforms (Basupi et al., 2019).

Pastoral livestock farmers also adopt a particular transhumance as another adaptation strategy. In particular, the herd departure from the PZ to a foreign country starts at the beginning of the rainy season. This kind of cross-border transhumance is specific to the PZ, as herds in general usually go on transhumance in the hot dry season (Gnoumou et al., 2020). In the cold dry season, most herds return to the PZ to take advantage of crop residues. At this point, the mostly seasonal fields have been harvested. Some livestock farmers ask permission from farmers to graze their crop residues after harvest, while some farmers ask specific livestock farmers to graze their crop residues and to keep the herd in their fields to benefit from the organic fertilization provided by the animals' droppings. This period opens up opportunities for social links between farmers and herders. Livestock farming and agriculture seem to be activities whose reconciliation will help the emergence of a sustainable livestock farming-agriculture production system. It is recognized that mobility and the integration of agriculture and livestock are the two pillars of West African livestock development (Gonin, 2018; Swarnam et al., 2024). In the face of climate change, the practice of agropastoralism, meaning combining livestock production with farming is a more resilient system than pure pastoralism (Tofu et al., 2023).

Livestock migration is also an adaptation strategy consisting of destocking the herd by sending large numbers of cattle to a neighboring country, mostly Ghana. The head of the household generally stays in his native land and converts to agropastoralism by

intensifying agricultural production. They combine other activities such as trading to improve the family's income. This livelihood diversification is an adaptation strategy also mentioned by other researchers in the context of climatic constraints (Kima et al., 2015; Abdou et al., 2020).

During the rainy season, the herds graze illegally within the classified forest. This choice was made despite the fines imposed by forestry officials for illegal grazing. The work of Kiéma (2007) and Sawadogo (2011) shows that protected areas are subject to grazing pressure and the removal of ligneous forage. High grazing pressure can be a source of decline in woody vegetation by suppressing juvenile growth (Ouédraogo et al., 2015). The edges of the roads and the areas around the concessions also provide much of the herd's food in this period. These pastures are of mediocre quality, with a dominance of observed species that include *Sida rhombifolia* L., *Senna obtusifolia* (L.) H.S.Irwin & Barneby, *Triumfetta rhomboidea* Jacq., *Cantinoa americana* (Aubl.) Harley & J.F.B.Pastore, *Mesosphaerum suaveolens* (L.) Kuntze. In situations of fodder shortages, unpalatable fodder species are heavily consumed (Ouédraogo et al., 2021).

## Drivers of pastoral livestock adaptation strategies to institutional reforms impacts

The Fulani ethnic group is characterized by herd mobility strategies and livelihood diversification. They are mainly pastoralists and are mostly installed by State authorities in the PZ. They have a nomadic lifestyle, moving with their herds in search of better breeding conditions. The disruption of pastoral livestock farming forces them to turn to other activities to support their livelihoods. In addition, they are mostly targeted by literacy programs in the local language and actions of organizations working to improve livestock farming practices and livelihood conditions. The training courses include grass mowing, silage fodder, and the manufacture of nutritional blocks for herders. This explains that haymaking is a feed practice mostly adopted among the Fulani. Ethnicity and knowledge are known to drive or influence the adoption of forage production strategies (Sanou et al., 2024).

The Nouni are also landowners with the privilege of disposing of fallow land where they can exploit the grass. The Silmi-moose are intermediate communities between the Moose, known as farmers, and the Fulani, who are herders. They combine livestock farming with farming, which could explain why they rent land to expand their farms. This category could possess large reserves of crop residues, which would make it ideal for fattening. This improves farmers' income and fodder security (Koutou et al., 2016b).

Livestock farmers who have purchased land, in search of a land-secured tenure are characterized by grazing around dwellings and along roads. They tend to be sedentary and keep their herds nearby.

## Pastoral livestock farmers' typologies in response to institutional reforms

Faced with the occupation of the watering point, livestock migration to another country is the principal adaptation strategy of livestock farmers. Water is a very important and irreplaceable resource for herd nutrition. The lack of this resource has negative implications

for the herd's life. When this challenge of water availability is seasonal, herders can remedy the situation by adopting transhumance (Kiéma et al., 2014; Gnoumou et al., 2020). However, when the difficulties of providing water for the herd occur over extended periods, migration to another locality is unavoidable. Livestock farmers concerned can be called "Cross-border herders."

With rangeland shrinkage and conflicts between herders and farmers, illegal grazing inside the protected area is a correspondent adaptation strategy. Illegal grazing in the classified forest could reflect a need for fodder to feed the herd, but above all a way of avoiding conflicts with farmers. In this way, the classified forest provides a refuge for the livestock during the rainy season. Pastoral livestock farmers expressed pastureland shrinking can be called "Encroaching herders" (Figure 8), and those that most raise conflicts are the "Conflicting herders."

The typologies of pastoral livestock farmers reveal that institutional reforms generate cascading pastoral constraints. The starting point would be the occupation of livestock watering points, pastureland shrinking, and conflicts between herders and farmers. Confronted with these changes, a mixture of adaptation strategies have been adopted, but the ones most concerned by the impact of institutional reforms are livestock migration and illegal grazing in the protected area. The highlighted challenges of pastoral livestock farming, related to resources management reforms, as well as the responses developed by livestock farmers, argue that the efficiency of livestock production depends on appropriate government policies as endorsed by Jiang et al. (2019).

## Conclusion and recommendations

The effects of institutional reform on pastoral livestock farming were analyzed in the sub-humid area through the PZ of Yallé. It appears that land tenure reforms and changes in protected area governance have led to contestation of the PZ's legality, favoring the land sale, and their conversion into farmlands. This resulted in difficulties in watering the herd, leading to herd migration to neighboring countries. The changes are also reflected in the reduction of pastoral space and the recrudescence of social conflicts between farmers and herders, driving grazing pressure on the protected area. Herd mobility, combining multiple strategies to satisfy herd feeding and socio-professional conversion of pastoral communities are employed to maintain livestock farming and fulfill producers' livelihood needs. The new fodder exploitation techniques promoted by training programs and the integration of livestock farming with agricultural activities are opportunities to strengthen the resilience of farmers through agropastoralism. It is necessary to involve stakeholders on the field to restructure space by considering the requirements of concealing livestock farming and agriculture. It is also helpful to consolidate tolerance between farmers and herders to revitalize social cohesion weakened by competition for natural resources. The state of woody resource conservation in the "PZ-Protected area" complex requires analysis to provide guidelines for its sustainable management and/or restoration.

It is recommended that policymakers ensure that sectoral actions for livestock development are adequately secured legally and that appropriate institutional reforms on resource management guarantee the common use of resources in both managed and unmanaged





**FIGURE 8**  
Cattle herd of “Encroaching herders” on a rural road in the pastoral zone of Yallé.

pastoral areas. We also recommend that livestock farmers establish community structures in collaboration with other producers to ensure local and coordinated mechanisms for resource management and conflict resolution in pastoral spaces. Furthermore, we advocate that state institutions, in partnership with municipal authorities, supervise the establishment of investors in pastoral zones and guide their activities through specific regulations, without granting them private property rights over the land.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be at: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Ethics statement

This study was conducted in accordance with the local legislation and institution requirements. The consent of participants was taken and they remained anonymous.

## Author contributions

BI: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Visualization,

Writing – original draft, Writing – review & editing. AZ: Conceptualization, Methodology, Supervision, Validation, Visualization, Writing – review & editing. IT: Conceptualization, Methodology, Validation, Visualization, Writing – review & editing. LB: Conceptualization, Methodology, Validation, Visualization, Writing – review & editing. RG: Validation, Visualization, Writing – review & editing. OO: Conceptualization, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing.

## Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. This study was supported by the “Projet d’Appui à l’Enseignement Supérieur (PAES),” implemented in Burkina Faso, funded by the World Bank (reference number P164293, don IDA D357-BF).

## Acknowledgments

We thank specially the “Projet d’Appui à l’Enseignement Supérieur (PAES),” which entirely financed this study. We also thank Sawadogo Idrissa, the chief veterinarian in the Pastoral Zone of Yallé. Thank you for Barry Ousmane in Yallé, our main guide. We would also like to thank the forestry officials in Neboun and Biéha. We thank the local people and resource persons in the study’s



localities. Thank you to the pastoral development Department of Agriculture, Animal, and Fisheries Resources for their encouragement and advice. We are also grateful to Zoungrana Adama, PhD, in the Laboratory of Plant Biology and Ecology of Université Joseph KI-ZERBO of Burkina Faso, for his support in analyzing the data.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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