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Resilience strategies of West African pastoralists in response to scarce forage resources

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Abstract

Finding sufficient natural fodder resources to feed livestock has become a challenge for herders in the Sahel zone of Burkina Faso. Despite the existence of pastoral reserves, the issue of fodder shortage remains unsolved. This article highlights the changes in behaviour and the evolution of pastoral practices caused by the scarcity of forage resources. These changes are defined and classified as resilience strategies. Thus, this paper aims to analyse these strategies using new semantics that calls for other forms of perceptions or approach to the questions of pastoralists' resilience strategies. Interviews (semi-structured and casual conversations), ethnographic observations and ethnobotanical surveys were used to collect data. In rangelands, such high value fodder species as *Andropogon gayanus*, *Pennisetum pedicellatum* and *Dactyloctenium aegyptium* that were abundant herbaceous plants during the last decades are disappearing. Concomitantly, species with lower forage value, such as *Senna obtusifolia*, which are more resilient to ecological disturbance factors, are colonizing rangelands. Faced with these ecological changes, pastoralists are trying to redefine and reconfigure their practices, and this implies a redefinition of their identity. They use resilience strategies such as mowing grasses, building up fodder bundles, conserving crop residues, exploiting *Senna obtusifolia* (a previously neglected species), using woody fodder and adapting the type of livestock and the size of the herds to the ability of pastoralists to feed them. Strategies that are older than these are the integration of agriculture with livestock and decollectivized transhumance. It is these resilience strategies that this article exposes and analyses as defence mechanisms of Sahelian pastoralists in the face of the depletion of forage resources in their environments.

Keywords: Pastoralism, Forage values, Burkina Faso, Ecological changes

Introduction

Drylands have a climate characterized by highly variable rainfall (Whitford and Duval 2019). Under these climate conditions, flexible and adaptive strategies such as mobility are required to buffer the high spatio-temporal variability of forage resources on rangelands (Niamir-Fuller 1999; Martin et al. 2014). Here, livestock remains the most important source of income for rural populations (Kaufmann et al. 2019). Mobile pastoralism is still an important

component of rural livelihoods, including those in sub-Saharan Africa (Bollig and Schulte 1999; Herrero and Thornton 2013). It is also a well-documented example for locally adapted and sustainable livelihood strategies (Reid et al. 2009; Martin et al. 2016).

In recent decades, however, traditional pastoral strategies in sub-Saharan Africa have been severely affected by global environmental changes (Safriel et al. 2005; Linstädter et al. 2016). These changes have had tremendous effects on pastoral livelihoods (Martin et al. 2014) and on pastoralists' resilience strategies (Krätli 2008; Turner et al. 2014; Kaufmann et al. 2019). Among the factors that constrain pastoral

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activities in sub-Saharan Africa, the most important ones are those related to increasingly scarce and unsecure forage resources. Here, effects of climate change such as a higher frequency and intensity of drought events are frequently discussed (Ayantunde et al. 2015; Kima et al. 2015; Zampaligré and Schlecht 2018). In contrast, the mechanisms by which pastoralists manage to sustain themselves in these changing environments and feed their livestock require more in-depth consideration. Indeed, in context of extreme events, people use various strategies to increase their resilience (Décamps 2007).

Resilience refers to the functioning of a system. It refers to a set of responses and progressive adaptation to disturbances in a system (Tukamuhabwa et al. 2015). It is therefore this quality of bouncing back and moving on in life after adversity (Earvolino-Ramirez 2007). According to Barroca et al. (2013), resilience refers to the ability of a system to absorb change and persist beyond a disturbance. It is a promising response to recurrent difficulties encountered. Applied to the specific case of pastoralists, resilience represents their capacity to resist and adapt to the effects induced by ecological and social changes (Korbéogo 2016). Resilience differs from vulnerability. According to the fifth IPCC Assessment Report (2014), vulnerability is the propensity or predisposition to be adversely affected. It implies sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

In West Africa's Sahelian zone, forage deficits during the scarce time of the year—at the end of the dry season (Linstädter et al. 2013)—have increased dramatically over the past years (Zampaligré and Schlecht 2018). While recent studies in West Africa have focused on the relative importance of climate change and land-use change on forage provision during the rainy season (Ferner et al. 2018; Guuroh et al. 2018), little is known on the influence of forage scarcity on behaviours of locals, particularly the strategies that pastoralists use to sustain and rebound after changes in their environments. In other words, the mechanisms through which observed forage deficits influence socio-cultural practices, and how they modify pastoralists' resilience strategies are—despite recent insights from animal tracking studies (Teitelbaum and Mueller 2019)—still poorly understood.

To overcome these research gaps, this paper aims to analyse how pastoral social-ecological systems in West Africa's Sahel zone are restructured in the context of increasingly scarce and unsecure forage resources. Indeed, pastoralist peoples practised extensive livestock rearing under a mobile system with two variants: nomadism and transhumance (Ancey 1997; D'Aquino 1998). With the increase of environmental degradation factors affecting pastoralism, settlement processes have been initiated to allow

for the diversification of livelihood activities (Boussim et al. 2004; Hellendorff 2012; Gonin 2014). Since then, the pastoral system has been evolving regularly and pastoralists are developing new practices and strategies to adapt or strengthen their resilience system. At the core of our analysis is to better understand the interdependency between the dynamics of forage resources, and the genesis of concomitant social or pastoral practices. The whole work was built on the following questions: how does the depletion of forage species influence the practices, practices and values of pastoralists? What strategies have they developed to deal with the depletion of forage resources?

Study area

The Sahel region of Burkina Faso is located between latitudes 12° 38' and 14° 18' north and longitudes 1° 33' and 2° 55' west. Climate is arid, with temperatures generally ranging from 15 to 45 °C. Mean annual rainfall is 464.5 mm, with the rainy season usually lasting from June to September (Ouédraogo 2012; Bonkian et al. 2017). Vegetation types are desert grasslands and shrublands (Kiéma et al. 2014). Woody thorny plants including *Balanites aegyptiaca* and *Acacia tortilis* among others make up much of the vegetation on the plains; the region is also dominated by annual herbaceous cover and *Piliostigma reticulatum* species in the valleys (Lykke et al. 1999; Schmidt et al. 2010). In addition, in recent years, several woody and herbaceous species such as *Acacia nilotica*, *Prosopis juliflora*, *Senna obtusifolia* and *Schoenefeldia gracilis* are flourishing in the area.

Traditionally, the region has had a strong pastoral propensity. Today, pastoral activities and cereal cultivation are at a household or village level to improve food security (D'Aquino 1998; D'Aquino 2000). Among the local ethnic groups, the Fulbe and the Bella are mainly pastoralists, while Moose and Gourmantché are mainly farmers. This study focuses on the pastoral groups, the Fulbe and the Bella, because they represent the key actors for our research questions. The Fulbe are made up of the Ferobe and the Gaobe who are said to have their origins in Mali as well as the Matube also known as Rimaïbe (they use to be the slaves of the Ferobe and Gaobe people). The Bella are a sub-group of the Tamasheks, a Sahelian people from North Africa. Like the Rimaïbé, they use to be slaves of the Touaregs, another sub-group of the Tamasheks.

The Fulbe used to live mainly on livestock products (milk, meat, etc.), but this food source is now supplemented by cereal holdings. Indeed, the ecological crises of recent decades have led to changes in their mode of production, in particular the association of farming with livestock. Their economy was mainly based on livestock or on the money from the sale of animals. Today, mining is more attractive to cadets, who see it as a source of personal or individual gain, rather than livestock, which

is seen as a common asset. The Bella people also make a living from farming and breeding. In addition to these means of subsistence, they rely on their artisanal knowledge (manufacture of seccos, *palisades* (door woven with the stems of *Senna obtusifolia* to close the huts), traditional mats, etc.) which provides them with a significant income. They are also recognized as the main sellers of firewood in the region. Like the Fulbe, they resort to gold panning in order to achieve financial independence. According to the elders, school and gold panning have won over the young people, who no longer like to invest themselves in livestock and agriculture.

Our research focused on three pastoral zones—a pastoral zone or reserve is an official delimitation of an area exclusively dedicated for livestock grazing—in Burkina Faso’s Sahel zone: Ceekol Nagge, Sambonaye and Kugari (Fig. 1). These zones were chosen due to their similar climatic conditions and are among the villages that were not affected by the recent terrorism attacks. The actors involved in the management of pastoral reserves are Burkina Faso’s government (as a

regulatory authority) and actors of the pastoral communities (as beneficiaries and local planners of functioning and exploitation).

Methods

Data collection

Qualitative approaches: the main techniques used

To analyse the restructuring of pastoral systems generated by the scarcity of forage resources, qualitative data collection techniques were used. We chose qualitative approaches because of their flexibility and capacity to deal with complex pastoral practices. Field surveys were conducted from November 2018 to November 2019. Data collection techniques included interviews (individual interviews, focus groups and ordinary conversation), ethnobotanical survey (Korbéogo 2009; Cunningham 2014) and ethnographic observation. These techniques were used simultaneously during the fieldwork, depending on practical opportunities such as meetings in households or meeting a herder transporting or collecting forage.

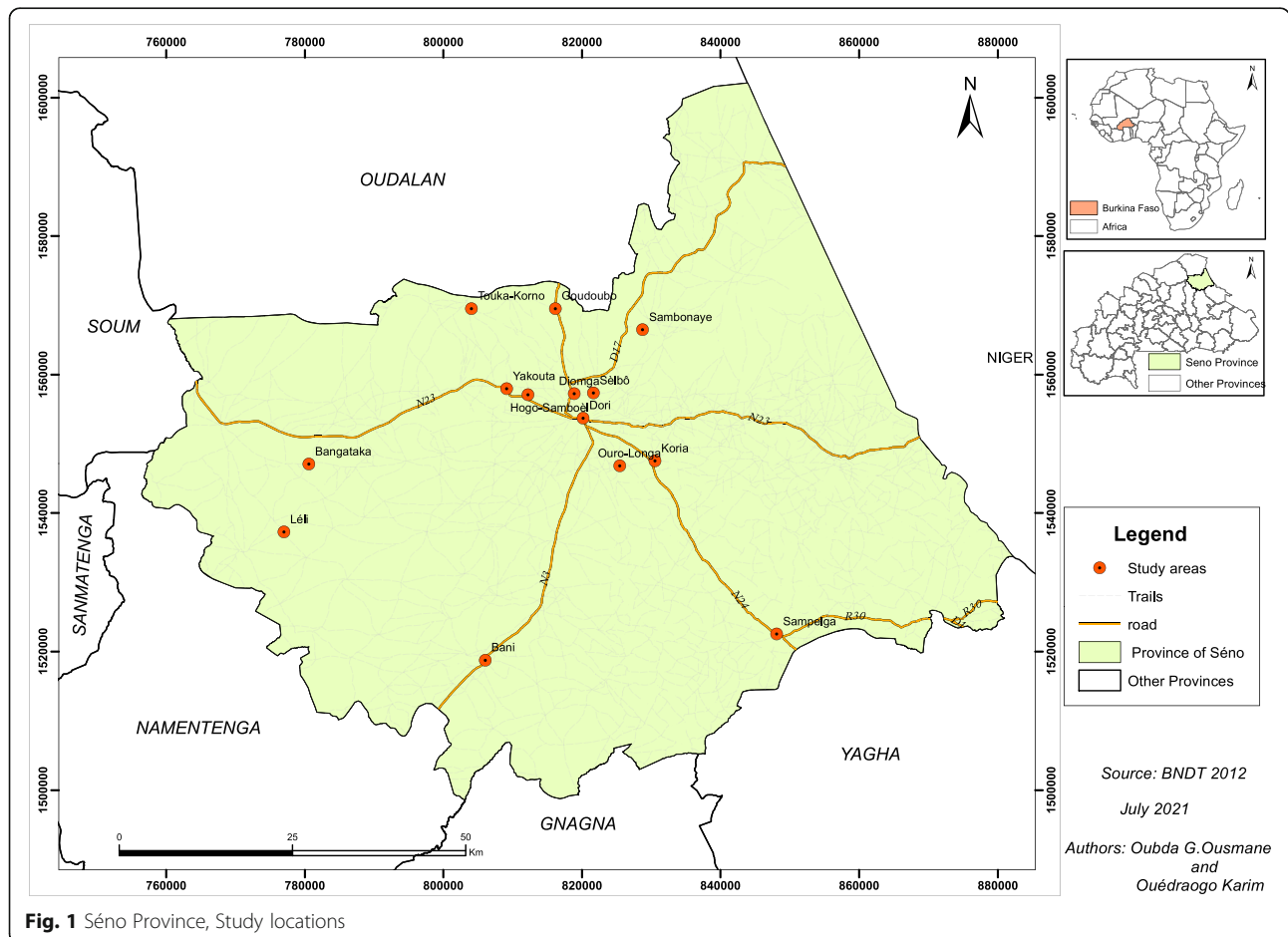


Fig. 1 Séno Province, Study locations

Conduct of field surveys

Both individual interviews and focus groups were considered as units of investigation. The duration of the individual interviews varied between 1 and 2 h, depending on the respondent's enthusiasm. Furthermore, with regard to group interviews or focus group, we took at least 2 h. We used a semi-structured interview guide to collect qualitative information on changing pastoral practices, habits and values in relation to observed dynamics of forage resources and species. Individual and group interviews were recorded with a dictaphone. Ordinary conversations, i.e. unplanned fortuitous encounters without the use of interview guide and a dictaphone, were also employed when applicable. The content of these discussions was noted down as soon as possible after leaving the informant. In this way, we avoided oversights. We conducted interviews (semi-structured interviews and ordinary conversations) in various places: in houses, on rangelands, at water points and on fields, at headquarters of certain services.

The ethnobotanical data collection was mainly in the form of a "qualitative inventory" of forage species during interviews. Specifically, we asked pastoralists, agro-pastoralists—pastoralists almost live on livestock and livestock products while agro-pastoralists are both herders and growers—and managers of ecological services to name known forage species with their vernacular or, if possible, taxonomic name. Hence, a free-listing exercise was used (as done in Naah et al. 2017). We went to the grazing field, accompanied by pastoralists to identify in situ these species on the list. Subsequently, we asked interviewees if the abundance of these species had roughly remained constant on local rangelands over the last three or four decades; or if abundances had changed (i.e. if species abundances had either increased or decreased, or if species had even disappeared). Respondents were also asked to indicate herbaceous species with low or high fodder value in local ecosystems.

Sampling

Data were collected from participants with either a direct link to pastoral activities (such as pastoralists themselves) or with an indirect link (such as growers). Participants included local herdsman and representatives of local authorities such as traditional chiefs and representatives of village development committees. Moreover, heads of pasture restoration organizations and representatives of governmental authorities such as foresters, heads of livestock structures and municipal councillors were also significant informants. In total, 27 individual interviews and three focus groups were conducted. Individual interviews were conducted in 11 villages including Touka Korno, Goudebo, Yakouta, Hoggo Sambowel, Selbo, Koria, Ouro-longa, Bani, Sampelga, Bangataka

and Léli with two participants per village. In Dori, the capital of the region, we conducted five individual interviews with livestock and environmental structures based there. Focus groups were conducted in Dori, Sambonaye and N'Djomga. In these locations, we first conducted a quantitative survey, the data of which are not included in this article. It was during this survey that we identified the participants from whom we collected this qualitative information. The respondents were individuals with extensive experience of pastoral activity, the evolution of pastoral practices and behaviours over at least the last four decades, changes in local ecosystems, vegetation dynamics, etc. Each participant, apart from those responsible for environmental services and pasture recovery organizations, was at least 50 years old. This age criterion allowed us to take into account local knowledge of the various changes from the rise of the environmental crises of the 1970s (Boussim et al. 2004; Boudes 2008) to their current exacerbation. Suspension of interviews is governed by the principle of saturation. At a certain point, the information was repeating, so we interrupted the collection.

The first focus group was consisted of 12 Fulbe from N'Djomga, the second of eight Fulbe from Sambonaye and the third of seven Bella (considered the main users of *Senna obtusifolia* in the region) from Dori. All groups were made up of men. The purpose of the focus groups was to gather information from the controversial view of participants. Focus group participants were identified in consultation with the representatives of the village development committees. The choice was based on their long experience with pastoralism, their knowledge of local ecosystems, their knowledge of forage species and their dynamics in time and space, the adaptation and resilience strategies they had developed, etc.

The observations focused on the forage provision of rangelands during the rainy and dry season. We observed the physiognomy of rangelands dominated by *Senna obtusifolia* in the rainy season. In rangelands, we observed certain species mentioned in the interviews. Within the villages, we also observed several strategies (conservation of crop residues, constitution of hay banks, grass mowing, etc.) that people develop in order to respond to the forage deficit they experience. We observed the local know-how in the manufacture of various objects and construction of the habitat (roofs, mats, seccos, fences) based on *Senna obtusifolia*. We participated in the constitution of fodder bundles in Dori and we also took part in a daily grazing of small ruminants in Sampelga. It is on this occasion of follow-up of the animals in the pastures in rainy season that we observed their behaviour in front of the dense clumps of *Senna obtusifolia*. We used an observation grid to collect these data. The observation grid is a tool for

collecting ethnographic data. It aims at the general observation of a research object to identify the relevant components. It includes a list of clues with sections for recording information about the elements observed (Robillard 1989, Dessus 2007).

Data analysis

Data analysis involved a formal match of plant species' local names to their scientific names. This was done by photographs taken of most of the species on the list drawn up during the interviews. In addition, several ecologists were present in the fieldwork, which allowed for the empirical identification of these species by their scientific names. It is therefore through these mechanisms that we have reconciled the local designations of these species with their scientific names. We then explored species' roles in local taxonomy and symbolism and their role in livestock feeding and mobility. The recorded interviews were subsequently transcribed into digital MS Word files and further processed following content analysis methods. Data collected through observation (mostly related to forage practices and resilience strategies) were compared with the information collected through the semi-structured interviews in order to restore the actors' logic between informative talks and facts on the resilience strategies developed. In other words, these data were used to bridge the gap between oral information and practical facts that reflect the resilience of locals.

Results

Local perceptions of rainfall failure and forage resource dynamics

Our results indicate that pastoralists and stakeholders in north-eastern Burkina Faso generally perceived current variation in rainfall as the main phenomenon that disrupted agro-pastoral activities. They were convinced that recent poor rainy seasons—they index especially these last three decades—greatly influenced forage production. In other words, rainfall failures—i.e. prolonged interruptions and short seasons—were perceived to have a negative impact on primary production, with negative consequences for rangelands' forage provision:

It is the insufficiency of rains. There are other fodder species that will grow when the first rains fall, but the fact that the rains do not follow each other regularly means that animals will graze them excessively and they will have difficulty to grow. When they fail to thrive during the rainy season, they die easily when the dry season comes. With time, they disappear little by little (Native Fulani, herder and grower, 67 years old, Ouro-Longa on 19/11/2018).

Environmental and anthropogenic constraints complicate the current pastoral condition. In addition to insufficient rainfall, the regeneration of plant species is further hampered and amplified by certain anthropogenic measures such as cutting plants for forage and habitat construction needs, and overgrazing. Some respondents state that to meet their needs, people from Fulbe and Bella as well as their animals have to intensively exploit species with high social and/or pastoral value. As a result, coveted species including *Zornia glochidiata*, *Andropogon gayanus* and *Pennisetum pedicellatum*, which are already very much affected by poor climatic conditions, are overexploited and overgrazed. These species—with the exception of *Zornia glochidiata*—have almost disappeared from the Seno's pastures. In the past, they provided multiform services to them and their livestock (roofing, secco, enclosures, traditional mats, forage). Nowadays, locals exploit *Senna obtusifolia* to meet some of these multiple services lost with the extinction of these species.

Grass and crop residue conservation as strategies to overcome forage deficit

Rangelands are the main sources of forage for pastoral livestock. Unfortunately, with the increased scarcity of forage species, pastoralists resort to other systems of feeding livestock. For example, the establishment of hay banks has become a common practice among several Sahelian pastoralists. Two objectives motivate this practice and two types of actors are involved. Livestock owners are seeking to address the issue of the lack of forage in the dry season especially from March to June. Those who do not own livestock seek to make an income by selling the hay—grass is cut from rangelands at the end of the rainy season between September and December—when standing grass is scarce during the long dry season. The establishment of hay banks represents a new way used to feed livestock and to adapt to the challenge of forage scarcity:

If you go back ten years the grass was lusher than it is today. In the years before that, no one really bothered to go and get grass from the bush to store at home. But in the last ten years, this has been the common practice of herders in the Sahel (Native Fulani, farmer and herder, 58 years old, Hoggosambowel on 29/10/2019).

These strategies end when the period of abundance in the rainy season comes. As soon as the rainy season ends, herders resume mowing and grass conservation. The grass species they mow to conserve are always the most palatable:

I immediately remove the grass to come and keep away from the sun and the rain, the last rains. Because generally I begin that towards the end of September and the beginning of October. At the moment there is still grass and I have time to go and remove it. The grasses that I mow are called “Bundia”, “Denguèrè” in Fulfuldé (Native Fulani, 37 years old, agropastoralist and project leader, Dori on 08/06/2018).

Bundia and *Denguèrè* are respectively *Zornia glochidiata* and *Trefrozia pedicellata*. Many other pastoralists keep these species mentioned by this agro-pastoralist, plus other species such as *Schoenefeldia gracilis* to feed their animals during the dry season. In addition, results from interviews and observations indicate that several pastoralists have chosen to switch to cereal cultivation in the Sahel. The benefits of this agricultural activity include the availability of cereals for food and the socio-economic complementarity between livestock and cereal crops; however, our interest is mainly on stored crop residues. In fact, the current turn in forage processes justifies the strategy of cereal residue conservation as mentioned in this interview excerpt:

We are currently forced to conserve crop residues to make up for this forage deficiency. Look at the roofs of the houses, there are millet stalks preserved all over the place (...). We are forced to keep millet stalks to feed our animals during the lean season (Native Fulani, grower and herder, 57 years old, Sambonaye, 21/11/2018).

The scarcity of herbaceous plants with a high forage potential in ecosystems forces pastoralists to conserve cereal residues (millet stalks, peanut and bean tops). It provides excellent forage for livestock. In most cases, motivation for conserving crop residues is not a financial gain, but rather to avoid spending money to buy forage for livestock. During the collection of these crop residues, locals expressly leave the stumps of *Sorghum bicolor* and *Pennisetum glaucum* in the fields (Fig. 2). This allows animals to find something to graze in the dry season and leftover stalks also enrich the soil for the next cropping season. This practice is another strategy they developed to strengthen the pastoral system.

Purchase of cottonseed cakes and grass to compensate for the forage deficit

One of the resilience strategies of pastoralists is the purchase of cottonseed cakes. They buy these cottonseed cakes because the animals lack grasses to ingest, especially towards the end of the long dry season. A respondent describes this situation as follows:



Fig. 2 Photo of *Sorghum bicolor* stumps after harvest and forage collection

It is because the animals are short of grasses that cottonseed cakes still have to be purchased to compensate. I am 66 years old. When I was young, I didn't even know what cottonseed cakes are. (...) There were enough herbs. The main concern here is the lack of grass only there. We didn't even know what it is to feed an animal by using cottonseed cakes, cereal residues or hay. We didn't even know what it meant to feed cattle because there was fodder in rangelands. The use of cottonseed cakes as feed for cattle here is less than 10 years old. Today you are obliged to buy for cottonseed cakes as a supplement feed; otherwise, the cattle will die (Allochthonous Bella, grower, 66 years old, Hog-gosambowel on 17/11/2018).

With the recent rainfall crises, highly coveted grasses are gradually disappearing. Pastoralists now compensate the forage deficit by buying cottonseed cakes. According to the pastoralists—Fulbe like Bella—the climatic conditions used to be more favourable for pastoral practice but this has changed now. The scarcity of forage that plagues the livelihood of pastoralists leads some people to commercialize the grass. Although the region has several pastoral reserves, pastoralists are struggling to feed their animals—many species with high feed value have disappeared from the ecosystems—according to the usual standards. Many of them necessarily pay for grass to supplement livestock feed. The scarcity of forage resources thus imposes almost unprecedented behaviour change on local actors. According to respondents, competition for forage has intensified over the last two decades. The low supply of forage from rangelands leads to commercialization of grass:

Those who own livestock mow the grass to preserve for their animals, but those who do not have

animals mow grass to sell. Whether herders or non-herders, both take it. Even if you are a herder and you manage to build up a large stock of hay that is not ready to be finished before the new grasses of the next rainy season, you will be able to take some of your stock to sell (Native Fulani, herder, 70 years old, N'Djomga on 27/10/2019).

Some people take advantage of the fact that grass is increasingly becoming a scarce commodity to build up stocks to sell to those in need. The majority of grass sellers do not generally own herds. Nevertheless, they go to collect grasses only for selling when forage becomes increasingly scarce in rangelands.

Woody forage species use to compensate forage deficit

Pastoralists also use woody plants (those that are available and have ingestible parts) to feed livestock. It is mainly the pods of woody species such as *Acacia nilotica* that are harvested to feed the animals in the dry season. As for tree leaves, pastoralists report that the cutting of leafy branches to feed animals, coupled with climatic aridity, has contributed to the disappearance of species such as *Pterocarpus erinaceus*, *Pterocarpus lucens* and *Azelia africana*. Therefore, it is now difficult to find tree leaves for the animals.

Changes in perceptions on *Senna obtusifolia* and its use to address the forage deficit

In spite of the abundance of *Senna obtusifolia* in the pastures, herders have not sought to valorize it, and they have not developed any conservation strategy for this forage. There are two main reasons for this: it is very abundant and accessible, but also and above all, it has a low fodder value. The scarcity of forage partly due to the proliferation of *Senna obtusifolia* in the rangelands has led to different views among the population. Some of them consider it as a threat to ecosystems because they say that this species grows in dense clumps that prevent the development of other less resistant grasses, while others believe that it is a resource that saves people and livestock in period of food shortage. Those who prefer the invasion of rangelands by *Senna obtusifolia* argue that in a context of climatic deterioration, any natural resource capable of facilitating more resilient existence becomes a valued commodity, as this excerpt shows:

It's not that we like "uulo" or that we are not worry about its expansion. It's something that is invasive and which hinders the development of other species; when you consider all this, it is worrying. But you don't have any choice under the circumstances. In the dry season, it's only "uulo" that manages to save our animals because people mow down other

forage species to sell. But no one can remove "uulo" to sell, its leaves will fall off when it starts to dry out. It is this species that helps our animals to survive in the dry season (Native Fulani, grower and herder, 67 years old, Ouro-Longa on 19/11/2018).

Uulo is the term used by Fulbe for *Senna obtusifolia*. Bella call it *kanaga*. Unlike some forage grasses, herders do not cut it to feed their animals later or to sell to others. The species that are mowed and sold are those that have a high feed value and are easy to preserve. But as for *Senna obtusifolia*, people say that its leaves are easily detached, which makes its conservation difficult. In addition, it is a less palatable species. However, owing to their awareness of the advanced degradation of soils in their areas and their unsuitable state for the regeneration of several herbaceous plants, some farmers are more favourable to the occupation of rangelands by *Senna obtusifolia*. Thus, their perceptions about this species are changing more and more, as are their grazing habits.

The forced ingestion of low-value fodder plant *Senna obtusifolia* in the Sahel

Senna obtusifolia is an abundant species in the Sahel. The history of its expansion is recent, of about a decade. The scarcity of high value palatable forage species is changing animal and human approaches to the plant. In our various conversations with pastoralists, it is clear that animals only consume *Senna obtusifolia* when forced to do so. In other words, this grass is not one of the highly coveted forage resources by livestock. However, it remains the only species they have to rely on to survive during periods of starvation. In ecosystems that offer almost no alternative, locals and livestock end up over-exploiting *Senna obtusifolia* (Fig. 3).

Small ruminants graze *Senna obtusifolia* particularly when its leaves and pods dry out. Large livestock such as donkeys, cattle and camels do not enjoy it as feed, but the scarcity of forage resources in recent years has led to a change in the diet of animals. In other words, the livestock have relatively adapted to this species and ingest it to ensure their survival in this context of forage scarcity. When more palatable forage species are available, *Senna obtusifolia* is neglected. Livestock behaviour changes as forage quality on offer changes. This logically explains why animals from different localities have different reactions to the same species of grass:

Animals from Tinakof, for example, don't have the same feeding behaviors as those are in the Dori area or elsewhere; you will notice that animals from here disdain *Senna obtusifolia*. But if you go to Tinakof



Fig. 3 Stands of *Senna obtusifolia* in the pastoral zone of Ceekol Nagge

as soon as the first rains fall, animals start grazing it because they have no choice. That's it! So that's a bit like that. Animals have been accustomed to the diet, especially the sheep (Researcher at INERA, 50 years old, Ouagadougou on 19/10/2018).

When other more palatable forage species are available in sufficient quantities in the pastures, animals abandon *Senna obtusifolia*. As forage becomes scarce, they become accustomed to it.

Forage deficit: pastoralists adapt livestock type and size of livestock herd to their ability to feed them

The size of the herd and the type of livestock determine the pattern of settlement, i.e. with or without livestock. Perfectly sedentary people are owners of small ruminants or a very small number of large ruminants (less than thirty head of cattle). When the herd is numerically large, the owner appoints one of his own family or uses the services of a salaried shepherd to carry out the pastoral movements. As forage resources have become scarce, grazing livestock by crossing international

borders is becoming more common today. This process is indispensable for pastoralists who practise large-scale livestock farming. The greater the herd, the more mobility becomes mandatory for herders and their animals as explained in this excerpt:

Because since the time of Sankara in 1983, which I noticed, grass is not enough for the animals. Anyone who has at least 100 head of cattle or 70 or even 60, he is obliged to move with his animals or he will sell some animals to buy and store some grass. Otherwise, he won't be able to bear it. (Native Fulani, herder and grower, 60 years old, Yakouta on 17/11/2018).

The preferred destinations remain the neighbouring countries. The pastoral movements of eastern Burkina Faso are oriented towards Togo, Benin, Niger, sometimes Ghana and Ivory Coast and those of the Sahel mainly towards Mali and Niger. Movement with livestock also implies proximity and familiarity with potential grazing areas. This justifies the migratory choices of

pastoralists from one pastoral area to another. The current scarcity of pastoral resources (forage and water) is the major constraint for livestock:

Before, there were not many animals but there was enough grass to feed them. They had enough until the rainy season came and found dry grass in the pastures. Now there are a lot of herders and a lot of animals too. Therefore, the grass can no longer be enough. (...) If the dry season lasts longer, there are other pastoralists who leave elsewhere with their cattle to come to us because of the dam (Native Fulani, grower and herder, 57 years old, Sambonaye on 21/11/2018).

This lack of forage resources forces pastoralists to develop this resilience strategy by redefining the type of livestock and the size of herds to own:

Nowadays the animals are like a burden for the pastoralists. There is no more grass in the rangelands to feed them because it does not rain properly anymore. Currently, we lack fodder for the animals. This is why many people prefer to get rid of their large herds (Native Fulani, grower and herder, 55 years old, N'Djomga on 26/10/2019).

Pastoralists who want to remain sedentary are the ones who make the most use of the strategy of adapting the type of livestock and the size of the herd to the resources available. This means reducing herd size by selling some livestock or simply choosing to raise small ruminants. This allows them to balance the animals they own with the forage available on pasture and especially with the forage they keep (hay bundles, crop residues, cottonseed cakes). This system relieves them of some overwhelming or tedious movements.

Integrating agriculture with livestock to strengthen local resilience

Pastoralists claim that current ecological changes have profoundly altered their socio-cultural habits in the Sahel. Some nomads have settled down in order to strengthen their resilience capacities. For most of them, settlement is a strategy of sustainably preserving their cultural heritage in a context of harsh climatic conditions. From this perspective, they perceive livestock breeding and cereal cultivation as two interdependent activities in their current socio-cultural organization:

We used to be pastoralist, but that's over now. We have become farmers. We relied on animals for a long time as a subsistence activity. But if animals

are dying and you have to sell the rest in order to minimize losses, you will certainly look for other solutions by changing profession. When we were children our parents were already farming, but not to a significant extent. It was when we grew up that we got more involved in cereal farming. During our parents' time there were enough animals for the stability of the household. It was in our time that the bad seasons began. Now, if because of bad seasons we have poor cereal yield, we have to sell the remaining animals to make ends meet (Native Bella, grower and herder, 55 years old, Kosarè on 03/12/2018).

The forage species that used to give the herds strength have almost disappeared. This forage deficit is consciously or unconsciously accompanied by a reduction in the number of heads per herd in order to reach the balance. This reduction in herd size is forcing pastoralists to turn massively to cereal production. Many pastoralists have turned into agro-pastoralists. However, pastoralists rarely become full-time farmers.

Discussion

Low availability of forage and interest in *Senna obtusifolia*

We found that pastoralists mainly perceived increasing rainfall deficiencies as negatively affecting fodder resources. Our results corroborate findings of earlier studies from sub-Saharan Africa in general (Bollig and Schulte 1999; Allsopp et al. 2007) and from West Africa in particular (Ayantunde et al. 2015; Kima et al. 2015; Zampaligré and Schlecht 2018). Besides these effects of scarce rainfall, increasing overgrazing and rangeland degradation was also highlighted by local actors as having detrimental effects on forage provision. These observations are in line with data on increasing livestock numbers in Burkina Faso. It is now common to find herds belonging to Moose and Gourmantché (These two ethnic groups were traditionally cultivators, but later they became interested in animal husbandry. Many became owners of large herds of animals.) in the region, in addition to herds belonging to pastoralists from other regions. Such an increase in livestock densities will inevitably have negative effects on rangeland health and may even lead to rangeland degradation.

A decisive aspect of this section of the analysis is related to the forage species of social and/or pastoral importance. They are indeed excessively exploited for any purpose, and their ability to produce and reproduce is thus affected. The exploitation of fodder trees is in line with this. Zampaligré et al. (2013) have shown the importance of these fodder trees for animals. However, this is an unsustainable strategy if it goes beyond pod

collection. Cutting leafy branches hinders the regeneration of species regularly targeted for forage needs. Unfortunately, some respondents stated that this practice has already negatively impacted woody populations in the Sahel. In this regard, Hien et al. (2021) noted that excessive collection of non-timber forest products for food and fodder renders several species vulnerable. This practice is therefore a contributing factor to plant scarcity. In contexts of climatic aridity, species with a high fodder potential and a high social utility disappear immediately. This leads local populations to turn to *Senna obtusifolia*, a resource that is very accessible in all villages of the region, to strengthen their resilience system. This species is classified as an unpalatable one by Hiernaux et al. (2016). However, in our context, livestock consume the dry pods and leaves of this species. In other words, animals have gradually become accustomed to graze this species.

This process of accustoming animals to this diet is naturally imposed on to them. Three decades ago, very little was known about *Senna obtusifolia*. Today, it is central to ecosystem needs and concerns. The fundamental reason for listing *Senna obtusifolia* as a feed species is the severe lack of diversified nutritious forage resources. *Senna obtusifolia* is a lean season feedstuff. Its nutritional potential can only be seen when animals and people have no alternative when it comes to satisfying their dietary needs.

From traditional methods to recent livestock feeding practices

The use of crop residues or cottonseed cakes in livestock feed in the Sahel does not represent a situation of intensification of the pastoral system—in the sense of Moritz (2012)—but a means of strengthening resilience. Indeed, fodder declines as the rainy season progresses (Babatoundé et al. 2010). February to June mark the most difficult periods for animals. This period is always synonymous with periods of incessant travel as they can no longer maximize their energy balance—with reference to the *Optimal Foraging Theory* (Dumont 1995; Roguet et al. 1998)—by staying put. The principle of mobility is very relevant for livestock. However, owners of small cattle herds or herds consisting only of small ruminants consider that mobility is disadvantageous.

The decline in herbaceous forage during the dry season rightly justifies this initiative to store crop residues or buy cottonseed cakes. These local strategies for feeding livestock are not conducive to the expansion of animal herds. On the contrary, the days of large herds seem to be over for the simple reason that pastures are now very poor. Herds of cattle of a certain size are driven to nearby or distant pastures by dedicated shepherds. Many of the herders impute the reduction in herds to the lack

of grass in quantity and quality. Aware of the harsh lean periods, farmers trigger the resilience process—explicable by the concept of tactical adaptation of the forage system (Lemaire 2008)—from October. The synopsis of the phenomenon is as follows: poor grazing due to insufficient rainfall leads the populations to develop fodder conservation strategies. Given the influence of low rainfall, especially on the quantity of forage, they now resort to cottonseed cakes to compensate for the deficit.

New pastoral practices developed

From an ecological point of view, grass cutting exacerbates the fodder deficit situation—it strips the pastures of their grazing potential—that the area is experiencing. However, the concern for the welfare of the livestock and the precarious socio-economic situation of the populations sometimes predisposes them to intensive exploitation of natural resources. These behaviours are the nefarious effects of the scarcity of forage resources in this environment. When pastures are rich in forage species, the practice becomes meaningless; no herder will invest financially in what is abundant and naturally accessible. Locals are becoming less interested in the resources that are fairly available and accessible. The *Senna obtusifolia* case is illustrative of this fact. We have not observed any farmers who valorize the species as livestock feed for the lean season. Nevertheless, in circumstances where there is an increase of forage deficit, animals and populations tend to fall back on available or accessible species. The interest in certain plant species that were previously neglected thus becomes a logical consequence. When pastorally or socially coveted species become extinct, survival instinct, that is, the quest for means of resilience, leads populations and their livestock to turn to other previously unused species. The consumption of *Senna obtusifolia* in the Sahel is a means of strengthening local resilience for both populations and livestock. The work of Kiéma et al. (2008) on the forage value of *Senna obtusifolia* tends to valorize it as livestock feed. Apart from the initiative of a feeding system that will add value to this forage resource, animals do not make this species a forage of choice; it has a “low ingestion value” (Babatoundé et al. 2010). However, periods of starvation are presented as a situation of compromise or minimal contentment in which livestock force themselves to ensure their survival and reproduction (Roguet et al. 1998) by ingesting *Senna obtusifolia*.

The scarcity of forage species has made them expensive and has thus changed the forms of approaches. It was not common—except for existential issues or issues of major social importance (Korbéogo 2014; Korbéogo 2016)—to see a herder selling his livestock to buy something as natural as grass. However, environmental

changes have forced each one to rethink the practice of pastoralism. Aspiring to crystallize the bases of their original activity, livestock farmers practise cereal cultivation in significant proportions. This farming practice prevents them from selling their livestock to buy food. In the current functioning state of local systems, the reciprocity or interdependence of these agro-pastoral activities is contributing to a redefinition of the social identity of the pastoralists. The strategy of paralleling the two activities so that they provide reciprocal services has become a local production mode in the Sahel. A rainy season unfavourable to good cereal production compels the populations to resort to their previous way of living; the livestock is put on the market to feed the household. This is consistent with the work of Turner (2017) who states that drought-induced cereal crop failures lead to mobility to well-watered pastures or the exchange of livestock for grain. In order to increase the chances of good cereal production, animal droppings are used as fertilizer in the fields (Turner et al. 2005; Guérin and Roose 2017). That is another important part of the strategy of integrating agriculture to pastoralism.

Mobility for forage resources and the issue of space

The pastoral peoples of the Sahel have several officially demarcated pastoral zones for the practice of large-scale animal husbandry. Burkina Faso has several pastoral zones, particularly in its Sahelian and Sudano-Sahelian zones. Beyond these pastoral zones specific to Burkina Faso, there is the Liptako-Gourma region, which is home to the W Regional Park, an important transboundary biosphere reserve where transhumant herders transit and stay. The management of this regional natural park is entrusted to Burkina Faso, Niger and Mali. This availability of large grazing areas should enable animals to feed themselves properly without crossing regional boundaries. But the shortage of forage in these zones requires moves to other areas with more herbaceous species. In our study area, the main problem is the lack of forage resources. These issues of forage resources and space have been discussed previously—some in different phyto-ecological contexts—and we will try to discuss them with the results we have obtained.

Pastoral activity in Burkina Faso is today confronted not only with a problem of space—Kiéma and Fournier (2007) and Vall and Diallo (2009) have carried out work along these lines—but also and above all with the availability of forage resources in terms of quantity and quality (Ferner et al. 2018; Zampaligré and Fuchs 2019). This deficient state of forage resources now implies specific forms of spatial relationships. By its very nature, pastoral activity is characterized by strategic movements. Referring to Moritz et al. (2010), Turner et al. (2014) and Rasmussen et al. (2018), the movement towards a given

horizon is based on the existence of indispensable elements such as pastures supplied with forage species and water points. Bonfiglioli (1992) adds that a minimum of security for both the shepherd and his animals is required. The problem of space and forage resources limits the mobility or migratory possibilities of pastoralists. It is therefore imperative to define a territory and rights (Gangneron 2013; Hiernaux et al. 2016), aspects that any sedentarization process requires. The adoption of the sedentary system as a way of life evokes an acculturative type of the pastoral system as a whole. Ecological conditions, including plant dynamics, influence the ways in which pastoralist groups organize or function. When plant resources change, the behaviour of locals and animals changes accordingly.

Changes in the pastoral system and evolution of socio-professional identities

Pastoralism is well-known to be nomadic or transhumant. However, current ecological changes have profoundly altered the socio-cultural habits of pastoralists in the Sahel. Following the logic of the usual patterns, mobility contributes to strengthening the resilience of pastoralists (Adriansen 2008; Gonin 2016). As Krätli and Schareika (2010) said, “environmental variability is a fundamental problem that pastoralists ‘solve’ by moving”. Today, this mobility has been rethought and redefined in the Sahel. Indeed, the reduction of grazing areas, the issue of forage resources and the remarkable increase in the number of family members are now leading people to opt for decollectivized mobility (one or a few members of the family lead livestock to rich pastures). Thus, ecological changes lead to structural and/or functional changes in pastoral systems. The way of life of pastoralists is gradually being reshaped by these changes. Changing practices, redefining or restructuring social identities as well as socio-cultural values become the alternative principle. On this point, many pastoralists are converting to cereal cultivation. Formerly pastoralists, they are now cereal producers. Shepherds are now engaged in the task of grazing animals at both local and regional levels. For Turner (2017), the Fulbe identify themselves as livestock breeders although they practise agriculture and animal husbandry. In our case, the “definitive” sedentariness has allowed the pastoralists to acquire large areas for agricultural activities. This is the reason why we sometimes use the term reconversion, since many of them now rely more on cereal production than on livestock to feed their families.

Having enough food to feed the family requires the head of the household to sell several goats. Unlike the analyses of Aquino (D'Aquino 1998)—he states that the reasons for combining cereal crops with livestock are economic—the objective sought in cereal production is

not primarily to reap economic benefits. The economic complementarity between agricultural production and livestock production that he discusses proves to be inappropriate to account for the agro-pastoral context we are dealing with. In this context, cereal crops are an essential means for preserving livestock, symbolically perceived as a perpetual legacy. Cereal crops avoids the sale of livestock for food and forage. Perhaps, the threats to pastoral activity today have led pastoralists to favour the cultural vision to the detriment of economic choices. This could explain the difference in findings between the two studies in this now highly agro-pastoral zone. In any case, it is still difficult to exclude the economic dimension of livestock farming practices even if, in the context of pastoralism, it occupies a subsidiary position.

Conclusion

Forage scarcity is a reality in the ecosystems of the Sahelian zone of Burkina Faso. Given the harsh impact of forage depletion on local livelihood activities, particularly pastoralism, populations are developing multiple strategies to maintain themselves in this context of ecological crisis. Thus, their habits, practices and socio-cultural or pastoral values have been profoundly modified or restructured. Things that were not part of their operating system have become common practice in this region. These include forage conservation practices like grass mowing, woody species pods collect, crop residues conservation, purchase of hay and cottonseed cakes and use of *Senna obtusifolia* as a supplementary food and feed. Prior to these practices, resilience strategies such as sedentarization, integration of agriculture with livestock and decollectivized mobility had already been initiated to circumvent the problems that endangered pastoral activity. When forage resources are in flux, herders try to reconfigure their practices, which implies a redefinition of their socio-cultural or socio-professional identities. Logic assumes that any forage resource dynamics implies a reconfiguration of pastoral systems. It remains now to find the ways and means to optimize some of these strategies such as the valorization of *Senna obtusifolia*. Indeed, the depletion of forage species of high social and pastoral value that led to the exploitation of *Senna obtusifolia* has also allowed people to realize that it is a plant with multiple uses.

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Authors' contributions

OO, AL, GK and OK conceived the sampling design; OK and ZA conducted the field surveys. OK analysed the data and wrote the manuscript. All co-authors improved it before submitting it to the review. The authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

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The authors state that there is no particular interest associated with this manuscript.

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