Vol. 14(30), pp. 1311-1325, 25 July, 2019
DOI: 10.5897/AJAR2019.13878
Article Number: 258E26161487
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Changes in livelihood strategies and animal husbandry practices of pastoralists in the sub-humid zone of West Africa

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Received 15 January, 2019; Accepted 16 May, 2019

Migration to and sedentarization in the sub-humid zone of Burkina Faso has become a major adaptation measure of Sahelian pastoralists to the severe droughts and in response to a rapidly changing socio-economic environment. This study is aimed at assessing livelihoods and livestock husbandry practices as a consequence of pastoralist sedentarization. The study sites were located in the Sudano-Sahelian and Sudanian zone of Burkina Faso. Findings revealed that severe Sahelian droughts of 1973/4 and 1983/4 led to massive migration and sedentarization of Sahelian pastoralists to their current locations in the sub humid zones. Since then, the sedentarized pastoralists have diversified their livelihood strategies in which livestock keeping and small-scale crop production play a central role. As the study sites are close to urban areas, a market-oriented local dairy production has also been developing. Overall, the total annual revenue of the sedentarized households and the size of their cattle herd have increased in tandem with the time they have been sedentarized. However, there are still some constraints and challenges such as restricted access to valuable pasture areas during the rainy season and recurrent herder-farmer conflicts that need to be addressed to strengthen the livelihoods of the sedentarized pastoralists.

Key words: Pastoralism, livelihood diversification, sedentarization, sub-humid zone, West Africa.

INTRODUCTION

In many West African countries, livestock production contributes significantly to the national economy, providing food security, income, employment, and substantially contributing to the gross domestic product (GDP) (OCDE/SWAC, 2009). Across Sahelian countries such as Mali, Burkina Faso and Niger, the total number of domestic animals is estimated at about 60 million cattle and 160 million small ruminants, which together

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contribute to about 20 to 30% of the agricultural component of GDP (CILSS, 2010). Among this huge number of livestock, transhumant pastoralism involves 70 to 90% of the cattle and 30 to 40% of the goats and sheep in the Sahelian zone, supplying about 65% of cattle and 40% of small ruminant meat (OCDE/SWAC, 2009). Historically, Sahelian pastoralists and their livestock were able to move freely across the landscapes, benefiting from the resources available in arid, semi-arid and sometimes also sub-humid environments. But today their ability to adapt to a changing environment is constrained by increasing climate variability and socio-economic transformation processes that occur in the region. The severe droughts of the 1970s and 1980s significantly reduced the Sahelian livestock population and threatened pastoral communities' livelihoods (Nelen et al., 2004). High human population growth across West Africa has profoundly altered land-use patterns and intensity, as well as livestock numbers, species composition of national herds and livestock management (Turner et al., 2005; Dicko et al., 2006). As a result, the mobility of pastoral livestock herds has been drastically reduced and human and livestock population growth have also led to increased competition between livestock keepers and crop farmers for the use of the available natural resources (Moritz, 2006; Bidima, 2011; Sanfo et al., 2015). These changes increasingly challenge the adequacy of nutrition for extensively managed ruminant stocks in the pastoral and agro-pastoral Sahelian zones of West Africa (Le Houérou, 2006) and today, these communities are suffering from the subtle and negative impacts of climate change and variability on their animals, access to drinking water and other pastoral resources and health (Brooks, 2006; Yoshioka et al., 2007; Sarr, 2012). At the same time, the ongoing changes negatively affect the vegetation of the grazing areas because confining livestock grazing to shrinking grazing areas leads to increased local grazing pressure and reduced livestock productivity (Turner et al., 2005, 2008; Bonnet and Herault, 2011). As an adaptation strategy, many pastoral livestock keepers have migrated and settled in the Sudanian zone. In fact, this strategy has been supported by the governments of some West African countries (Burkina Faso, Côte d'Ivoire, Mali, Niger and Senegal), and projects funded by the World Bank have created grazing areas or pastoral zones where, during the dry season, forage and water resources are relatively abundant (Nelen et al., 2004; Gonin and Gautier, 2015). Many of these zones are either around big cities or forested areas, including national parks and protected areas, where ranching systems are encouraged and livestock markets are also available (Basset and Turner, 2007). Immigration and sedentarization of Sahelian pastoralist in the sub-humid zone has induced some changes in their life style, livelihoods and production systems (Greenough et al., 2016). Basset and Turner (2007) reported the adoption of small-scale crop cultivation by pastoralist immigrants, and numerous studies investigated changes in the access to and governance of common pool resources such as pastures, water and agricultural land in the wake of immigration and sedentarization of Sahelian pastoralists into the sub-humid zone - particularly in Burkina Faso (Benoit, 1977; Bonnet and Herault, 2011; Nelen et al., 2004; Gonin and Gauthier, 2015; Gonin, 2016; Greenough et al., 2016).

But some knowledge gaps still exist regarding the current livestock wealth, and implications of household settlement in the vicinity of protected areas on the livelihoods and livestock management strategies of these sedentarized pastoralists. At the same time, such information is useful in furthering understanding of the potential ecological and socio-economic developments in the region, where human and livestock motilities are dynamic and often shift in line with global changes that are taking place at any point in time (climate change, rapid population growth and urbanisation). Therefore, this study sought to analyse the changes in sedentarized pastoralists' livelihood strategies and their livestock husbandry systems over time since their sedentarization in the sub-humid zone of Burkina Faso in the 1970s and 1980s. Specifically, the study objectives are to characterise the current livelihoods and livestock management practices of sedentarized pastoralists, and in other hand identify the determinants if their livelihood strategies as they settled. The following research questions were addressed: (i) What are the current livelihood strategies and livestock management practices of sedentarized pastoralists? (ii) What are the determinants of present livelihood strategies? (iii) Does the duration of sedentarization affect the pastoralists' livestock wealth?

MATERIALS AND METHODS

Study area

The study was conducted in 2014 at two sites, namely Nobere (Latitude: 11°12' and 11°50' N, and Longitude: 0°50' and 1°40' W) and Dinderesso (Latitude: 11°11'5'' and 11°18'1'' N and Longitude: 4°18'46'' and 4°26'40'' O), which are, respectively, located in southern and western Burkina Faso (Figure 1). The first site is located near Kabore Tambi National Park, the second near the classified forest of Dinderesso. The pastoral zone of Nobere is mainly occupied by sedentarized Fulani pastoralists, while the silvopastoral zone of Dinderesso is used by sedentarized Fulani pastoralists and peri-urban non-Fulani livestock keepers originating from Bobo Dioulasso, the second largest city of Burkina Faso. Both sites also serve as dry season grazing areas and transhumance corridors for pastoralists from other regions of Burkina Faso during their yearly transit to Ghana and Ivory Coast.

The Nobere pastoral zone (the "*Zone Sud Ouest*"), is located next to the national park. It comprises 32,000 ha of land and was delineated in 2005. It may be used for settlement, grazing, and small-scale crop cultivation by the sedentarized pastoralists. In Nobere's pastoral zone, there is a shortage of basic infrastructure. For instance, the community reported that they only have two

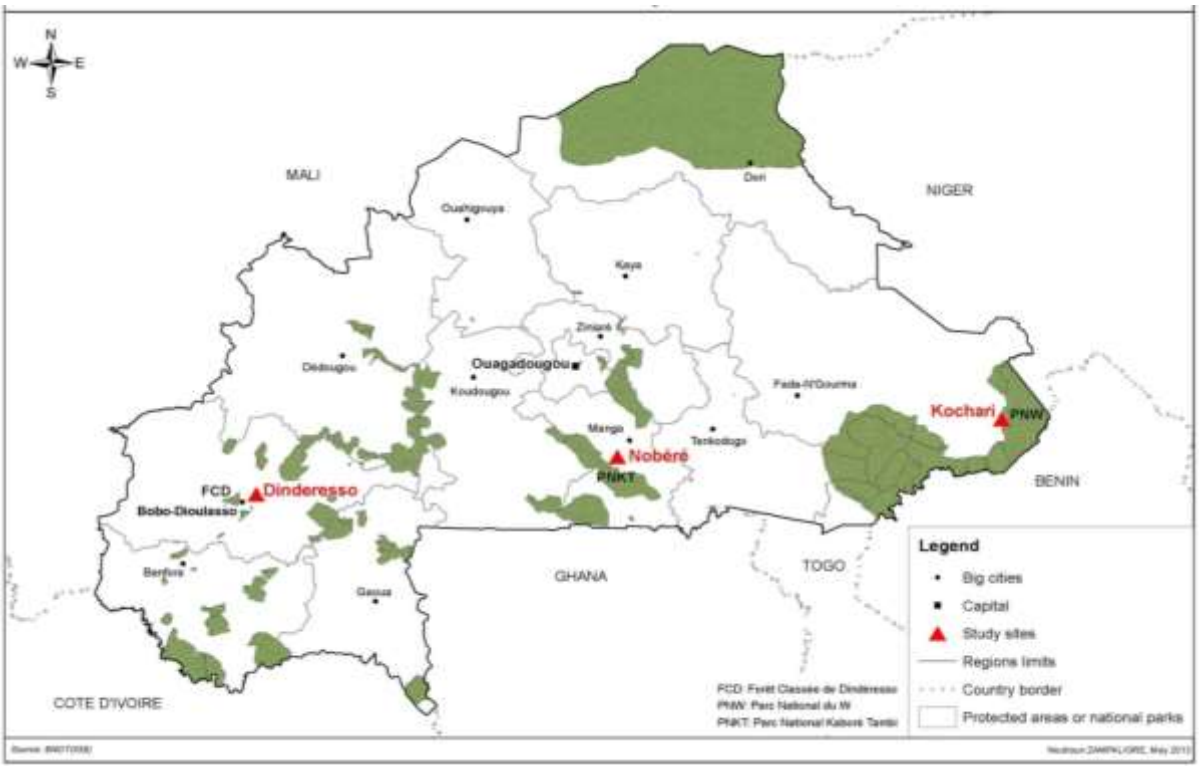

Figure 1. Study sites location in Burkina Faso.

manual pumps for fetching drinking water, one well, one rural bilingual school and one livestock vaccination park. A dam was constructed in the year 2000 for livestock herds, but their access to this watering point is very difficult especially during the rainy season due to crop fields that are located very close to it.

The silvopastoral zone of Dinderesso (2379 ha) was established in 2005 and is reserved for livestock grazing as part of the forest participatory management plan established in 2005. The Nobere pastoral zone is managed by a farmers' association, whereas in Dinderesso access to the silvopastoral zone is regulated by two associations (one representing the sedentarized pastoralists and the other representing the peri-urban livestock keepers). These committees organize the grazing system, make sure that their members respect the set grazing rules and assure the protection of the grazing areas against bush fires and illegal users. The committees are also actively involved in the governance of the community-based forest management system of the two protected areas.

The Dinderesso site is benefiting from its proximity to Bobo Dioulasso - there are livestock vaccination parks, livestock markets and veterinary services. A dam located in the grazing zone provides water to the herds and in each settlement there is at least one manual pump for drinking water. Most of the households are located far from schools and health centres.

Climate and vegetation

The site of Nobere is located in the Sudano-Sahelian climate zone which is characterized by an alternation of a dry season (November to May) and a rainy season (June to September). The average annual precipitation ranges from 600 to 900 mm with high spatio-temporal variation. Temperature also varies depending on month and season of the year, with the average annual temperature being 28°C. The area is drained by several important rivers including the Nakambé (Red Volta) and small seasonal tributaries.

The Dinderesso site is located in the South Sudanian zone and is likewise experiencing a dry season (November to April) and a rainy season (May to October) (Figure 1). The average annual precipitation ranges from 900 to 1200 mm and again shows high spatio-temporal variation. At both sites, the vegetation is typically of Sudanian type, dominated by trees, shrubs and C4 grasses, and shaped by the combination of climatic factors and anthropogenic influences such as grazing and fire. Along rivers, gallery forests are found (Coulibaly, 2010). The soils are mostly ferruginous tropical soils and a large portion of the protected areas are fallows and agroforestry parklands (Coulibaly, 2010).

Data collection

For this study, the methodological approach developed by Ellis (2000) was applied, which is a combination of sample surveys and participatory techniques, such as semi-structured focus group discussions and key informant interviews. These served to bring out a typology of livelihood strategies and detailed analysis of the roles and importance of income, activities and assets that sustain the livelihoods and wealth of the target community. More details regarding the approach and statistical analyses are provided in the following sections.

Focus group discussions and key informant interviews

Focus group discussions were held to obtain qualitative information. Two meetings were separately held at each site, the first one for mainly women, and a second for a mixed group of young herders, adults and elders men, all belonging to the group of sedentarized

pastoralists. Each focus group consisted of 8 to 10 persons. The qualitative information gathered from the focus group discussions served as the basis for designing the questionnaire for a household survey.

Household sampling procedure

A stratified purposive sampling procedure was adopted. First, villages surrounding the Kaboré Tambi National Park and the classified forest of Dinderesso were selected for the survey. Then, in each of these villages, sedentarized pastoralist households were identified and selected based on their primary livelihood activity. The number of respondents (one per household) was selected in proportion to the total number of sedentarized pastoralist households in each area; thus a total of 108 households were interviewed. In this study a sedentarized pastoralist household is defined as a previously mobile a pastoralist household that settled in its current location for at least one decade, with livestock rearing being a primary source of livelihood while secondary sources of livelihood are subsistence cropping and other off-farm activities (supplying at least 10% of household income and food sources).

Household survey

For the household survey, a structured questionnaire was administrated to the selected household head. Section 1 of the questionnaire focused on information about the respondent, the household characteristics and assets; section 2 referred to the household's economy; section 3 dealt with household access or ownership of physicals assets; section 4 and 5 focused on crop and livestock production systems. In addition, the questionnaires also covered the respondent's perceptions on the protected areas' natural resource availability and users' access to these, seasonality and change in resources quality and availability, as well as governance of the natural resources (section 6). The questionnaire was designed in French and administrated in local languages by trained enumerators. The questionnaire was pre-tested with 10 household heads who were not part of the final set of interviewed households.

Statistical analyses

Principal component analysis

Principal component analysis (PCA) in SPSS 22 (SPSS Inc., 2013) was used to explore the relationships between the different variables and to reduce the large number of variables to a smaller number of components for further analysis (Dossa et al., 2011). The rule of retaining the components that contain a minimum of four variables having a loading score >0.60 (Stevens, 1992 cited in Dossa et al. 2011) was used to extract the number of reliable principal components from the PCA (Dossa et al., 2011). As indicated by Dossa et al. (2011), the higher the loading of a variable on a given principal component, the more that variable contributes to the variation accounted for by this component. But as factor loading significance depends on sample size (Stevens, 2002), for this study variables with a loadings score >0.40 was retained on one of the retained components as meaningful components (Field, 2014) (Table 3).

Cluster analyses (CA)

A two step non-hierarchical cluster analysis was used to characterize the livelihood strategies adopted by sedentarized pastoralists in the study sites. Cluster analysis has been successfully used in several studies to characterize the livelihood strategies of pastoralists (e.g., Homewood et al., 2009). In this clustering approach, a set of procedures was followed. First, the principal component scores from the previous PCA was used as inputs for the cluster analysis in SPSS 22 (SPSS Inc., 2013). Secondly, before using the categorical variables in the cluster analysis, the continuous variables were converted into nominal variables using the visual binning procedure of SPSS 22 (SPSS Inc., 2013) because in the two-step cluster analysis, the higher weighting of categorical variables at the expense of the continuous variables in the clustering process may be an important issue (Dossa et al., 2011). Thirdly, the Bayesian Information Criterion (BIC) for retaining the number of clusters in this study was used. And finally, three clusters were obtained and a cluster name assigned to each. Once clusters were identified and names assigned, cross tabulations in SPSS 22 (SPSS Inc., 2013) was ran to show the distribution of each household livelihood activity and income contribution across the three retained clusters. Differences between clusters in household and farm characteristics, livestock wealth and financial assets were explored using the Kruskal–Wallis non-parametric test.

General linear model

A general linear model was used to examine the effect of years in residence at the study site on the households' livestock wealth and asset ownership. In this study, years in residence of the household head were defined as the total time that the household head had stayed at the site (ordinal variable). Three classes were defined based on results of the focus group discussions in which three major settlement periods of had been identified by the pastoralists themselves. Thus, class 1 depicted a residence maximum of 20 years ago (that is, recently settled); class 2 a residence ranging from 21 to 40 years (that is, settled after the severe drought of 1983/4); and class 3 a residence of more than 40 years (that is, settled after the severe drought of 1973/4).

RESULTS

Historical timeframe and trajectories of pastoralists' sedentarization

Narrative information gathered during focus group discussions and key informant interviews helped to draw historic timeframes and processes of Sahelian pastoralists' sedentarization in the sub-humid zone of Burkina Faso. Reasons and motivations behind their choice of particular sites were also determined. Here, results are first presented for the general case and then specific aspects pertaining to the study sites of Dinderesso and Nobere are highlighted.

General historical sedentarization process

Three distinct periods were identified as key periods during which pastoralists migrated from the Sahel to settle in their current sites. These periods were: (i) right after 1960 when the country got independent; (ii) just after the Sahelian drought of 1973/4; (iii) just after the Sahelian drought of 1983/4. In addition, there has also

been intermittent sedentarization of transhumant pastoralists at the study sites. Community members pointed to diverse reasons that motivated people to migrate and settle in their current locations. The first group of migrants settled due to their regular dry season transhumance to the area, as a good relationship was built with the villagers. Secondly, due to the severe impacts of droughts on the natural and cultivated vegetation in the Sahel, famine for humans and death of many animals, many pastoralists migrated and settled in the sub-humid zone. The latter situation was typical for the majority of households now living in the study sites (result of focus group discussions). Most of the sedentarized pastoralists originated from the administrative region of Sahel (Dori) and the central plateau region of Burkina Faso for Nobere, and from the northern region of Burkina Faso (Ouahigouya, Kaya administrative region) for Dinderesso. Preferred settlement places were peri-urban areas, the vicinity of protected areas and, in some cases, villages where the immigrants already had relatives.

The immediate post-drought migration and sedentarization has been supported and promoted by government, NGOs, and international development agencies through programs and projects that specifically targeted the relocation of pastoralists to the so-called pastoral regions in the sub-humid zone, which also included delineated transit and refugee areas for mobile herds.

Most of these programs aimed to promote the shift of Sahelian pastoralists from nomadism to a sedentary lifestyle, including more intensive livestock production approaches such as feedlot and ranching systems. These should replace the traditional extensive livestock production system which was identified as the main cause for land degradation and desertification in the Sahel. Except for the delineated pastoral zones, sedentarization was usually facilitated by a host in the destination sites who introduced the incoming pastoralists to community leaders and villagers. Pastoralists settling in the pastoral zones were given permission by local authorities who had agreements with traditional authorities.

In the pastoral zones, some of the key infrastructure such as dams, schools, vaccination parks, and extension services was put in place to support livestock production communities. This is the case for the first generation of delineated pastoral zones in Burkina Faso, namely CEZIET, SIDERADOUGOU, SONDRE-EST and NOUHAOU in Kénédougou, Comoé, Zounwéogo, and Boulgou provinces, respectively. The choice of specific areas to settle was guided by the relative availability of rangelands, animal feed resources and hospitality of local communities on the one hand. On the other hand, availability of job opportunities and market incentives for those who settled in peri-urban areas was a key determinant. Full sedentarization of the pastoralists was progressively achieved through household attachment to the territory, adoption of crop production for food consumption needs, and employment of household members as shepherds, which was particularly important for those who lost all their livestock during the droughts. Gains from cropping activities, earnings from waged herding as well as being involved in small jobs helped some households to rebuild the livestock herd lost during the drought and thus engage in livestock production once again. Nowadays most of the sedentarized pastoralists possess livestock and are also involved in crop production as well as in a number of other income earning activities. About 55.5% (Dinderesso) and 75.5% (Nobere) of household heads had settled in their current location for more than 20 years.

Specificities of pastoralist communities in Nobere and Dinderesso

The majority of pastoralists who are settled in Nobere are from northern central Burkina Faso (Kaya). According to the elders, initially (around 1960) there were only three households and today there are about 50 households, distributed across six (06) settlements along the border of the Kaboré Tambi national park. The park was already created when the migrants started settling, but from 2004 to 2007, due to the park extension program (PAGREN project), the households were relocated to the Nobere site in the buffer zone of the national park. The immigrants' main livelihood activities are livestock rearing, field cropping, livestock trade, petty trade and the use of non-timber forest products (NTFP), due their proximity to the national park.

At the Dinderesso site, according to the elders, the first pastoralist community settled around 1920 before the delimitation of the classified forest in 1951. After the demarcation of the classified forest, grazing was prohibited until 1983 when the government allowed grazing in the forest through the USAID/686 – 0235 project, but only during the lifetime of that project (5 years). Later, in 2004, another project, known as PAGREN (Projet d'appui à la gestion des ressources naturelles) created grazing areas in the forest for periodic grazing by livestock herds of the settled pastoralists. Those grazing areas are still open for controlled livestock grazing from June to January every year.

Current livelihoods of sedentarized pastoralists in the sub-humid zone

Household socio-demographic characteristics

All interviewed households were male-headed and mostly Fulani migrants (100 and 91.7% in Dinderesso and Nobere, respectively). Household sizes mostly ranged

Table 1. Socio-demographic characteristics of respondent households.

Variable	Dinderesso (n=57)	Nobere (n=50)
	Respondents (%)	Respondents (%)
Age (years)		
20 -30	7.4	10.2
30 - 40	16.7	26.5
40 - 50	29.6	30.6
50 - 60	22.2	20.4
60 - 70	18.5	12.2
>70	5.6	0.0
Education		
No education	20.0	68.8
Primary school	7.3	2.1
Secondary school	5.5	0.0
Informal education	5.5	4.2
Koranic school	61.8	25.0
Household size (members)		
5-10	50.0	59.2
10-15	28.6	26.5
>15	21.4	14.3
Duration of living in the village (years)		
5 - 10	21.4	8.2
10 - 20	14.3	16.3
20 - 30	17.9	26.5
>30	37.5	49.0
Ethnic group		
Fulani	91.07	100
Mossi	3.57	0
Bobo	3.57	0
Bolon	1.79	0

from 5 to 15 persons. The age of the heads of households ranged from 30 to 60 years for the majority. Among the respondents, the level of formal education was very low; 20 and 68%, respectively, in Nobere and Dinderesso, had no education and only 7 and 2% had primary and secondary level education (Table 1). About 68 and 20% of the Muslim respondents had attended Islamic school. The main livelihood activities were livestock rearing, small-scale crop farming, livestock trade, petty trade, wage earning, receiving remittances, and use of non-timber forest products (Figure 2).

Pastoral livestock keeping as main livelihood activity

In both study sites, livestock was the mainstay of the livelihoods of almost all households, and thus, all respondents owned some animals. Main species kept were cattle, sheep and goats. Besides these, donkeys were also reared by all interviewed households, mostly for ploughing fields and as a means of transportation. Herd sizes varied from 41 to 70 for cattle and from 14 to 23 for small ruminants. Livestock feeding practices were mainly based on daily grazing, and mobility (daily grazing movement within the village territory, small and long distances seasonal transhumances) was a key feature within the livestock feeding practices (Figure 3). About 50% of households in Dinderesso and 25% in Nobere were still practicing transhumance within the country. About 20% among these even practiced transboundary transhumance during the dry season (Figure 3). Preferred destinations for the transhumant herds included northern Ghana and northern Ivory Coast. Local grazing areas were fallowed fields, fields after crop harvest, and in most case also the vegetation of the protected areas although it is considered illegal for livestock to be grazed there except in the buffer zone for Nobere and the silvo pastoral zone for Dinderesso. Cattle herds were mainly composed of breeds of zebu cattle or cross-breeds between zebu and taurine cattle; for sheep and goats the Djalonké breed prevailed but in some cases Sahelian goats were kept. Next to the consumption of livestock

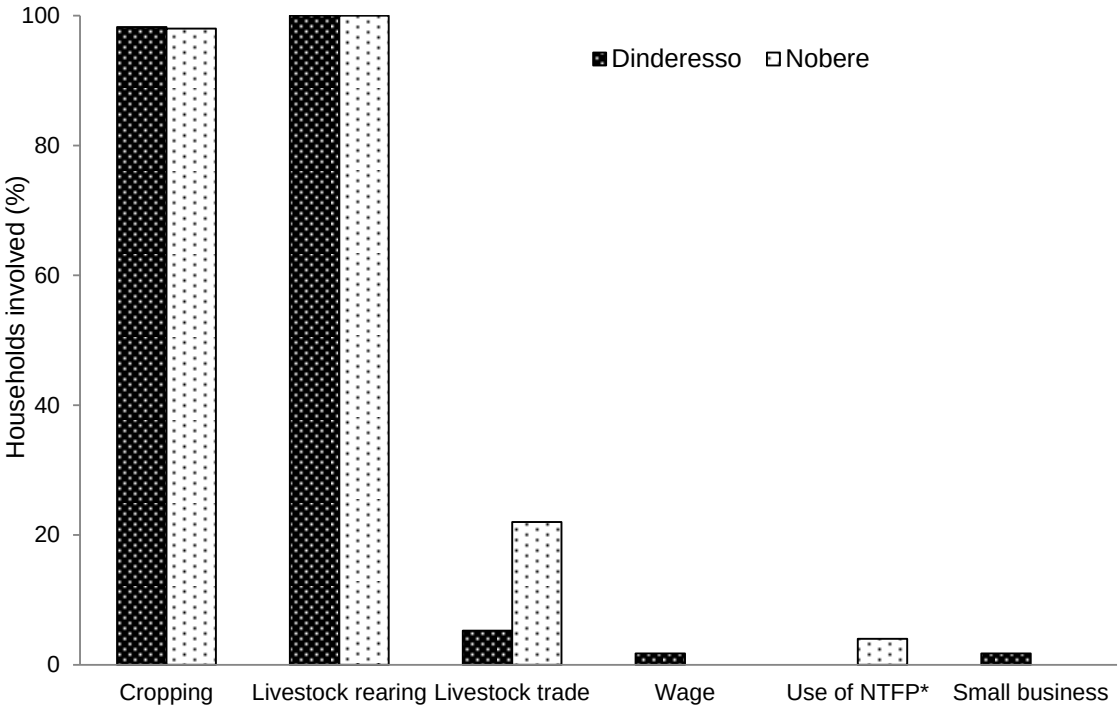

Figure 2. Proportion of households involved in different livelihood activities at the study sites. *NTPF: Non-timber forest products.

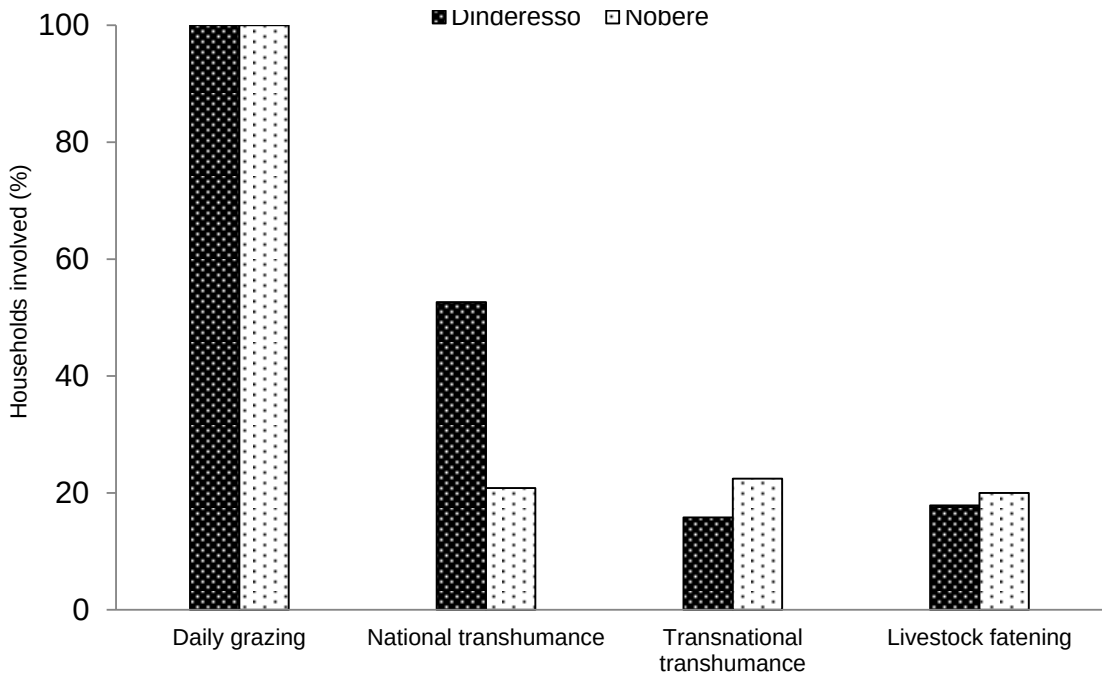

Figure 3. Current livestock management practices at the study sites.

products (milk and meat) consumption, most of the respondents derived the large share their income from the sale of live animals and cow milk.

Small-scale crop production

Results of the interviews indicated that even before

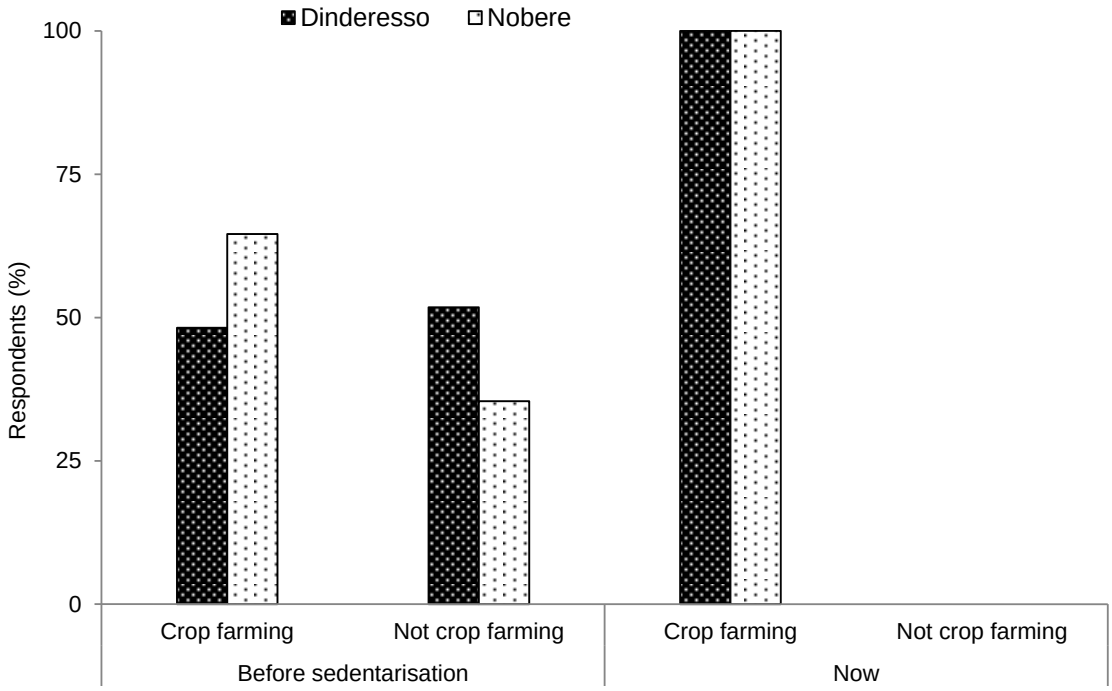

Figure 4. Changes in crop farming practice by sedentarized pastoralists.

Table 2. Species of staple (s) food and cash (c) crops cultivated by sedentarized pastoralists.

Crop (scientific names)		Households involved (%)	
		Dinderesso	Nobere
Millet *(Panicum glaucum)*	*s*	9.7	2.5
Sorghum *(*Sorghum *bicolor)*	*s*	*27.8*	33.3
Maize *(Zea mays)*	*s*	38.2	60.5
Rice *(Oryza sativa)*	*s*	2.1	0
Groundnut (*Arachis hypogaea)*	*c*	3.5	0
Cotton *(Gossypium* sp.)	c	3.5	0
Cow pea *(Vigna unguiculata*)	s, c	11.8	3.7
Sesame (*Sesamum indicum)*	*c*	3.5	0

sedentarization about half of the respondents had already been involved in small-scale crop production as another source of livelihood (48% in Dinderesso and 65% in Nobere). All the interviewees indicated that they actively cultivate crops in addition to keeping livestock (Figure 4). The crops include both cash and food crops, such as sorghum, millet and maize (Table 2). About 3.5 and 2.5% of the respondents also grow cash crops such as peanuts and cotton (mainly in Dinderesso). Cropland sizes range from 0.5 to 10 ha, with an average of 1.5 and 2.0 ha, respectively, for Nobere and Dinderesso. The interviewees reported that the adoption of cropping is a response to the disappearance of the former barter system of livestock products against field crops; it is geared at food consumption with the aim to reduce the costs of cereal purchase.

Other livelihood activities

Other livelihood activities reported by the respondents include livestock trade, petty trade, use of NTFP and wage earnings. About 5 to 22% of the respondents were involved in livestock trade at Nobere and Dinderesso, respectively. While petty trade and wage earnings prevail at Dinderesso, wage earnings and sales of NTFPs prevail at Nobere (Figure 2). These activities are mostly income-generating and their adoption depend on the main livelihood strategy adopted by the household (Table 4). The share of income from these activities is indicated in

Table 3. Model summary and component factor loadings of variables used in the principal component analysis.

Variable description	Rotated principal component factor loadings		
	PC1	PC2	PC3
Sheep herd size (n)	0.82		
Annual income from crops sold (in FCFA)	0.78		0.10
Cropland size (ha)	0.56		-0.19
Household size (n)	0.55		
Goat herd size (n)	0.53	0.13	
Agriculture income (yes/no)	-0.52		0.42
Head of household status (native/migrant)	-0.12	-0.78	
Annual remittances (in FCFA)	0.11	0.70	-0.13
Income from livestock trade (in FCFA)	-0.30	0.57	
Livestock fattening (yes/no)	-0.29	0.57	0.28
Total annual revenue (in FCFA)	0.40	-0.46	
Primary livelihood activity (1=C, 2=LR, 3=LT, 4=WE, 4=others)	0.15		0.87
Second livelihood activity (1=C, 2=LR, 3=LT, 4=WE, 4=others)			-0.85
Number of fields cropped	0.18	-0.17	-0.44
Number of years in residence		-0.24	0.15
Age of the head of household (years)		0.17	-0.15
Transhumance (yes/no)		-0.14	
Education of the head of household (level of literacy)	-0.12		0.21
Cattle herd size (head of animals)	0.34	0.14	0.24
Income from NTFP (in FCFA)		0.13	-0.18
Income from animal sales (in FCFA)		0.18	
Income from milk sales (in FCFA)			-0.20
Income from handicrafts (in FCFA)		-0.14	
Land ownership (yes/no)	-0.32	-0.23	
Eigenvalue	3.684	2.502	2.382
% of variance explained	12.99	9.48	9.27
Cronbach's alpha	0.62	0.15	0.56

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

Table 5.

Livelihood clusters

The cluster analysis identified three main livelihood strategies employed by the respondents, who could be classified as: (i) Subsistence agro-pastoralists with livestock dominance; (ii) Subsistence agro-pastoralists with crop dominance; and (iii) Market oriented agro-pastoralists. The categorization reflects a household's dominant activity, its diversification, and the income level as derived from the annual sales revenues (Tables 5 and 8). The subsistence agro-pastoralists with livestock dominance are households practicing livestock rearing and small-scale crop production as their main livelihood activities, with livestock being the primary activity (Table 4). The main source of income for this group is livestock, whereby 79.7 and 84.8% of the households are involved in live animals and extra milk sales, respectively. Livestock rearing is seconded by subsistence cropping with an average area of cropland of 1.9 ±1.48 ha. The average herd sizes are 54, 15 and 19 heads for cattle, sheep and goats, respectively (Table 5). In addition to the two main activities, few households of this group are engaged in livestock fattening (15.3%), livestock trade (20.3%) and use of NTFP (23.7%) as other livelihood activities. Transhumance is practiced by about 37.3% of the respondents during dry season mostly, toward Ivory Cost (for Dinderesso) and Ghana (for Nobere). The average time in residence of the head of household is 26 years and household size averages 10 members.

The second group, defined as subsistence agro-pastoralists with crop dominance**,** is made up of households practicing livestock rearing and crop production as their main livelihood activities, with subsistence cropping being the primary livelihood activity. About 20% of the income is generated from sales of surplus crops. The mean size of a farm is 2.3 ±1.72 ha, whereby each household owns at least two crop fields. Livestock rearing is the second most important activity, but herds are smaller than in the first cluster (Table 5),

Table 4. Frequency distribution of agro-pastoralists' (AP) involvement in livelihood activities and income earning.

Variable	Response	*Subsistence AP, livestock dominance* (n=59)	*Market-oriented AP* (n=13)	*Subsistence AP, crop dominance* (n=10)
Primary livelihood activity (yes)	Cropping	0.00	15.38	10
	Livestock rearing	100.00	84.62	90
Secondary livelihood activity (yes)	Cropping	100.00	76.92	10
	Livestock rearing	0.00	15.38	0
	Livestock trade	0.00	7.69	90
Livestock fattening	Yes	15.25	46.15	10
	No	84.75	53.85	10
Transhumance practice	Yes	37.29	38.46	90
	No	62.71	61.54	40
Income earning from crop sales	Yes	3.39	61.54	60
	No	96.61	38.46	20
Income earning from milk sales	Yes	84.75	69.23	80
	No	15.25	30.77	60
Income earning from live animals sales	Yes	79.66	69.23	40
	No	20.34	30.77	80
Income earning from livestock trade	Yes	20.34	53.85	20
	No	79.66	46.15	10
Income earning from NTFP sales	Yes	23.73	30.77	90
	No	76.27	69.23	10
Income earning from handicrafts sales	Yes	5.08	7.69	90
	No	94.92	92.31	0
Receiving remittances	Yes	5.08	0.00	100
	No	94.92	100.00	0

and households own on average 28 heads of cattle, 13 goats and 15 sheep. However, about 60 and 80% of the households in the second cluster also earn income from live animal and extra milk sales. Only 10% of households practice livestock fattening, livestock trade or make use of NTFPs (Table 4) as other livelihood activities. Transhumance is practiced by about 40% of the respondents but not beyond the national borders. Average time in residence of the head of household is 23 years and average household size is 10 members.

The third cluster comprises the market-oriented agro-pastoralists whose characteristics are similar to the subsistence agro-pastoralists with livestock

Table 5. Comparison of sedentarized pastoralists' agro-pastoralist (AP) resources across clusters (mean values and standard deviation, SD).

Variable	*Subsistence AP, livestock dominance* (n=59)		*Market-oriented AP* (n=13)		*Subsistence AP, crop dominance* (n=10)		*Sig.*[2]
	Mean	SD	Mean	SD	Mean	SD	
Household size (number of persons)	10.1[a]	5.72	17.3[b]	10.13	10.0[a]	7.42	*
Residence time (years)	26.6	13.50	28.8	11.66	23.6	16.79	NS
Crop land size (ha)	1.9[a]	1.48	3.7[b]	1.93	2.3[ab]	1.72	**
Cattle herd size (head of animals)	54.6[ab]	45.18	110.0[b]	128.37	27.7[a]	12.36	**
Sheep herd size (head of animals)	15.1[a]	9.22	37.9[b]	23.11	12.8[a]	7.10	**
Goat herd size (head of animals)	18.7[a]	14.05	37.7[b]	27.73	14.4[a]	9.91	*
Income from crops sold (x 1 000 FCFA)[1]	303.2[a]	239.82	821.2[b]	723.97	191.8[a]	181.24	**
Income from animals sold (x 1 000 FCFA)	1177.6	1 255.8	2561.4	2830.4	871.0	978.7	NS
Income from milk sold (x 1 000 FCFA)	313.5	535.8	414.4	469.4	130.7	165.9	NS
Income from livestock trade (x 1 000 FCFA)	304.9[a]	897.3	1819.2[b]	3457.7	200.0[a]	632.5	*
Income from *NTFP* sold (x 1 000 FCFA)	12.2	25.6	22.5	40.6	7.5	23.7	NS
Income from handicrafts sold (x 1 000 FCFA)	1.8	7.9	4.6	16.6	0	0	NS
Income from remittance (x 1 000 FCFA)	4.2	217.8	0	0	0	0	NS
Annual revenue (in 2014) (x 1 000 FCFA)	2117.4[a]	2116.97	5643.3[b]	4728.43	1401.10[a]	1112.11	**

[1]Currency in 0xFCFA (1 FCFA= 655.995 Euro); [2] Kruskal-Wallis test, significance level (*=p≤ 0.005; **= p≤0.001); for each variable and row, respectively, mean values with different superscript letters are significantly different.

dominance. Livestock rearing, milk production, cropping and livestock trade are their main livelihood activities, whereby 46.2 and 53.9% of the households practice livestock fattening and trade. Besides, home consumption of livestock products such as milk, most of the interviewed households are also earing cash from live animal and milk sales (94 and 100% of respondents, respectively). Total annual revenue is the highest among the three groups (Table 5), due to the diversified income sources, and cluster members also hold considerable livestock wealth (Table 5).

As depicted above, crop production and livestock rearing were the main livelihood activities of most of the 108 respondents across the two sites, but households further diversified their livelihood activities and income sources as indicated in Table 4. Results of the non-parametric Kruskal Wallis test indicated that a household's wealth (n) of cattle (H=10.91, p=0.004), goats (H=18.89, p=0.001) and sheep (H=7.39, p=0.025), its crop land area (H=7.39, p=0.025), revenues from surplus crops sold (H=10.87, p=0.004), revenues from livestock trade (H=8.46, p=0.015) and the total annual income (H= 16.66, p=0.003) were significantly affected by the cluster membership of a household (Table 5).

Analyzing the effect of years in residence showed that livestock wealth, especially ownership of cattle (F = 3.7993; *p = 0.26*) and the total annual revenue (F = 5.982; *p = 0.004*) were significantly different between the three classes of years of residence (Table 6), whereby cattle herd size and annual revenue significantly increased as years in residence increased (Table 7).

DISCUSSION

Current livelihood strategies of settled pastoralists

Findings from this study demonstrate that Sahelian pastoralists have settled in the sub-humid zone of Burkina Faso many decades ago as a consequence of the droughts in the 1970s and 1980s. Most of these sedentarized pastoralists have diversified their livelihood strategies but livestock remains the mainstay, although the majority of them is also involved in crop production as another important livelihood

Table 6. Analysis results on effect of year in residence on pastoralists' wealth.

Dependent variable		Sum of squares	df	Mean square	F	P-value
Annual revenue (0xFCFA)	Contrast	5.83E+13	2	2.92E+13	3.793	0.026
	Error	6.53E+14	85	7.69E+12		
Cattle herd size (n)	Contrast	45264	2	22632	5.982	0.004
	Error	321572	85	3783		
Goat herd size (n)	Contrast	688	2	344	1.691	0.191
	Error	17306	85	204		
Sheep herd size (n)	Contrast	249	2	125	0.408	0.666
	Error	25971	85	306		
Cropland size (ha)	Contrast	7	2	3	1.178	0.313
	Error	242	85	3		

The F-tests on effect of year in residence are based on linear independent pairwise comparisons among the estimated marginal means. Df=degree of freedom.

Table 7. Distribution of household assets and annual revenues according to years of residence (settlement) of pastoralists.

Households assets and revenues	Year in residence		
	≤ 20 years (n=28)	[21 - 40[years (n=58)	≥ 41 years (n=9)
Cattle herd size (n)	41(12)	56 (9)	122 (21)
Goat herd size (n)	15 (3)	20 (2)	13 (5)
Sheep herd size (n)	19 (3)	22 (2)	24 (6)
Cropland size (ha)	2(0.32)	2 (0.24)	2 (0.56)
Annual revenue (in 1 000 F CFA)	1373.2(524.0)	2785.2(388.2)	3945.6(924.2)

Values depict means and (standard deviation).

activity.

Similar observations on the Sahelian pastoralist movements from the Sahel and their sedentarisation into the southern agro-climatic zones as well as adoption of crop production have been reported by Bassett and Turner (2007) and McCabe et al. (2010). The results of the present study show that size of the livestock herd and of cropland, the practice of livestock fattening, the level of revenues from surplus crops sold, livestock trade, and total annual cash revenue characterize the type of livelihood strategy adopted by a particular household in the study area. This shows the change from specialized livestock keeping to an agro-pastoral livestock rearing system with adoption of activities that enable diversification of income sources. The prevalence of livelihood diversification among sedentarized pastoralists suggests that this is an important feature for household wellbeing and economic transformation, especially in the context of a rapidly changing environment and rural household vulnerability (Ellis and Allison, 2004). A diversified livelihood strategy reduces vulnerability compared to a specialised strategy, and might be more sustainable over time, because it allows for rapid adaptation to changing circumstances (Ellis,

2000). Pastoralists' livelihood diversification, including adoption of crop cultivation as a consequence of restricted access to key pastoral resources and reduced possibilities for herd mobility, have also been observed in East Africa (Kenya and Tanzania; Homewood et al., 2006; McCabe et al., 2010). Indeed, most of our interviewees pointed to the complementary benefits of crop and livestock integration for their livelihood strategy, the role of crop residues for livestock feeding and of livestock manure for crop field fertilization, as also stated by Tarawali and Hiernaux (2002) and Powell et al. (2004). Other activities such as the use of non-timber forest products and involvement in livestock trade are more site-specific given the present proximity to forested areas and urban centres, respectively. Livelihood activities both for food and income contribute to alleviate poverty, build substantial wealth (in the form of assets and animals) and reduce risks associated with rural livelihoods as well as the ongoing climatic and non-climatic stresses in the study area. The impact of the number of years of residence on animal wealth shows a positive effect of sedentarization, as livestock wealth contributes substantially to yearly cash revenues. This might be explained by the fact that years in residence in the sub-humid zone allowed sedentarized pastoralists to rebuild their herd and accumulate financial resources through diversification of income sources as discussed above. In fact, availability and relative abundance of natural resources (forage and water) for livestock rearing in the designated settlement areas (Sanou et al., 2018), and the possibility for earning off-farm income near or in urban centres led to livestock wealth accumulation, since traditionally and until today, surplus cash is invested in animals. Also, as market opportunities exist in these areas especially for meat and dairy products, livestock keepers have improved health care and reproductive management of their livestock to maximize their benefits. Since traditional rangelands are scattered and encroached upon by cropland, the only possibility for herders is to graze their livestock in the rainy season in the protected areas, damage to crops outsides these zones might lead to violent clashes between livestock keepers and crop farmers (Kiéma, 2007; Kiéma and Fournier, 2009). Similar grazing strategy during the rainy season is also observed (Zampaligré and Schlecht, 2017) in the Kaboré Tambi National Park where livestock herders of Nobere located in the vicinity of the park grazed their animals inside the protected area despite the grazing ban (Code forestier du Burkina Faso). However, grazing protected areas is organised and supported by governmental policy in Dinderesso, where a community controlled grazing system in the classified forest exist since 2005. This use of protected areas as rangelands by the resident former pastoralists as well as transhumant Sahelian pastoralists is a common problematic feature across (sub-humid) Sudano-Sahelian countries in West Africa who share borders with (semi-arid) Sahelian countries (Kagoné et al., 2006; Convers et al., 2007; Fournier et al., 2009). Initiatives and policies in favour of participatory protected area management involving livestock grazing and transhumance have been developed in recent years to mitigate possible negative effects of grazing on the protected vegetation (Kagoné et al., 2006). Periodic use of the classified forests as pasture, hay-making from the vegetation of the protected areas, and opening of grazing routes for access to watering points are among these initiatives and policies. In addition, there are regional agreements on pastoralism in favour of livestock mobility across Sahelian and coastal countries through the transhumance protocol of ECOWAS/CEDEAO (La décision A/DEC.5/10/98 relative à la réglementation de la transhumance entre les Etats membres de la CEDEAO du 31 October 1998). Studies showed that periodic grazing of livestock in the classified forest of Dinderesso is appropriate in case of full adherence to rules by the key actors and strict compliance with the governance system in place (Nacro, 2007; Coulibaly, 2010, Zampaligré et al., 2018). The experience indicates the possibility of involving pastoralists and farmers in participatory sustainable management of protected areas. Similar community-based resource management strategies of forage resources and forests involving local communities and pastoralists have been reported from elsewhere in Africa and worldwide (Bedunah and Schmidt, 2004; Nelson et al., 2009; Roe et al., 2009; Reid at al., 2014). These management strategies need to be considered when developing land tenure and grazing policies (Grings et al., 2016).

Current challenges and opportunities of pastoralism in the sub humid zone

As outlined in other sections of this paper, there is recent as well as historic migration from the Sahel and sedentarization of pastoralists in the sub-humid zone of Burkina Faso. Factors such as pastoral resources availability, eradication of Glossina (tse-tse) flies in the sub-humid zone, as well as the multiple benefits of integrating crop and livestock production have favoured pastoralists' settlement in the area. In addition, the growing market opportunities for livestock and livestock products as a consequence of increasing urbanization and human population density, with its subsequent increase in demand for food, are fostering sedentarized agro-pastoralism in the sub-humid zones of West Africa. There are some evident constraints and challenges to the development of sustainable sedentarized agro-pastoralism in the study area. Specifically, for our study sites, the main constraints are both the restricted access to grazing areas due to the presence of the park and protected areas (where livestock grazing is at least at times prohibited) and the expansion of crop fields, which

is a problem during the rainy season (Sanfo et al., 2015). Conflicts between herders and crop farmers over access to pasture resources, restricted access to protected areas, crop land expansion, and increased insecurity are some of the challenges reported by the communities during the survey. All these constraints need to be appropriately tackled in order to ensure sustainable and peaceful land use in the sub-humid zone of Burkina Faso. At the moment, there are untapped market opportunities that can easily be exploited to improve the sedentarized pastoralists' livelihoods. The rapidly growing urban population with its high demand for animal-based food (milk and meat) is a great opportunity for those keeping livestock. For instance, about 90% of cattle, goat and sheep meat consumed in Burkina Faso originate from the country's pastoral and agro-pastoral systems, which in addition also supply live animals for export to neighbouring countries. In 2011, about 371,873, 586,082 and 744,782 heads of cattle, sheep and goats, respectively, were exported to Benin, Togo, Ghana and Nigeria (FAO/ECOWAS, 2016).

In our study sites, due to their proximity to urban areas, some of the agro-pastoralist interviewed are actively involved in the livestock trade and play central roles as livestock traders besides being livestock keepers. Their strategic involvement as producers and traders helps them negotiate good prices and generate substantial incomes for their households. Beside live animal sales, there is also a growing urban demand for (local) dairy products where the settled former pastoralists can play a central role in supplying the markets. Until now, the contribution of local milk production to cash revenues is still very low, but we observed that most of the households that were interviewed are trying to benefit from the growing urban dairy market through retaining dairy cows from their herd and supplementing them with cotton seed cake and other concentrated feed during the dry season. At the study sites, about 60 to 80% of the respondents reported earnings from surplus milk sales, regardless of their cluster affiliation. Efforts by government, projects and NGOs are supporting the local dairy production through creation of innovation platforms for dairy production, processing and marketing (APESS, 2014), but little is done to improve the actual milk output of cows during the long dry season, which is basically a matter of appropriate feeding strategies.

Conclusion

Assessment of the current livelihood strategies and animal husbandry practices of sedentarized former Sahelian pastoralists in the sub-humid zone of Burkina Faso clearly show that these former pastoralists have diversified their livelihood activities, among which pastoral livestock rearing and small-scale crop production play a central role. These changes are on one hand a consequence of their new sedentary lifestyle, the socio economic and environmental conditions at their current locations. Thus, sedentarized pastoralists are also starting to take advantage of the growing market demand for livestock-based food in large cities, and especially market-oriented local dairy production has the potential to provide supplement incomes to settled pastoralists. But there are still a number of constraints and challenges that need to be addressed to allow livestock keepers to better benefit from those market opportunities, such as feeding strategies for the dry season, including fodder production, hay making and supplementation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENTS

This research was conducted within the framework of the Postdoctoral Research Program on "Resources, Livelihood Management, Reforms, and Processes of Structural Change in Sub Saharan Africa" (project number: 88088) funded by VolkswagenStiftung Hanover, Germany. We are thankful to the Institut de l'Environnement et de Recherches Agricoles (INERA) in Burkina Faso for the support provided in the implementation of this research. We also recognize and appreciate the participation of the pastoralists and agro-pastoralist communities in the study areas and their help in acquiring the data for this study.

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