'Where's the map?': integrating ethnography with maps to understand the complementarity between pastoral mobility and border formation

Elisabeth Kago Ilboudo Nébié [a1]

Colin Thor West [b]

Todd Andrew Crane [c]

[a] Columbia University, USA

[b] University of North Carolina at Chapel Hill, USA

[c] International Livestock Research Institute, Kenya

Abstract

The resettlement of herders in pastoral zones is often criticized for hindering pastoral mobility, which is essential to survival. We integrate narratives of conflict and environmental change with maps to demonstrate the complementarity between pastoral mobility – porous borders – and border demarcation – rigid borders. We use evidence from the Sondré-Est Pastoral Zone in southern Burkina Faso, where herders were voluntarily resettled near agricultural villages following the droughts of the 1970s. Over time, however, farmers encroached on the borders of the pastoral zone and surrounding grazing areas declined. This increased land-use disputes. Tensions were exacerbated by the fact that these communities kept maps as community secrets. We re-created the administrative boundaries of the pastoral zone to map land-use/land-cover changes and conflict hot spots. The maps show that conflicts happened along porous borders where agricultural fields encroached. Herders called for a clear demarcation of the border of the pastoral zone to preserve exclusive access to resources within it. Simultaneously, they also wanted to maintain shared access to other resources outside the pastoral zone. The herders' desire for both border clarity and some form of flexibility underlines the complementary between both processes, especially in times of resource scarcity and land-use conflict. The mystery around the maps helps sustain ambiguity that is key for pursuing both goals.

Keywords: GIS, land-use and land-cover change, farmer-herder border conflicts, pastoral mobility, Sahel, Burkina Faso

Résumé

La réinstallation des éleveurs dans les zones pastorales est souvent perçue comme étant une entrave à la mobilité pastorale, essentielle à la survie dans le Sahel. Nous associons les récits sur les conflits et changements environnementaux à des cartes pour démontrer la complémentarité entre la mobilité pastorale – nécessitant des frontières poreuses - et la démarcation des frontières – imposant des frontières rigides. Nous utilisons comme exemple la zone pastorale de Sondré-Est dans le sud du Burkina Faso, où les éleveurs ont été volontairement réinstallés près des villages agricoles à la suite des grandes sécheresses des années 1970. Au fil du temps,

---

[1] Dr. Elisabeth Kago Ilboudo Nébié, postdoctoral research scientist, International Research Institute for Climate and Society (Earth Institute) and Lamont-Doherty Earth Observatory, Columbia University, USA. Email: ilboudo_nebie "at" iri.columbia.edu. Dr. Colin Thor West, Associate Professor, Department of Anthropology, UNC Chapel Hill, USA. Email: ctw "at" email.unc.edu. Dr. Todd Crane, Climate Adaptation Scientist, International Livestock Research Institute, Kenya. Email: t.crane "at" cgiar.org. We would like to thank the reviewers and acknowledge funding from ILRI and World Agroforestry Center, Wenner-Gren Foundation, PEO International, the Norman Borlaug Leadership Enhancement in Agriculture Research Program, and the Graduate School and the Initiative for Minority Excellence at UNC Chapel Hill. The Carolina Population Center at UNC Chapel Hill provided general support through its NIH Center grant (P2C HD050924).

cependant, les agriculteurs ont empiété sur les frontières de la zone pastorale, diminuant ainsi les zones de pâturage environnantes. Cela a accru les conflits d'utilisation des terres entre éleveurs et agriculteurs. Les tensions sont exacerbées par le fait que les cartes montrant les limites réelles de la zone pastorale sont gardées comme des secrets communautaires. Nous avons recréé les limites administratives de la zone pastorale pour cartographier les changements d'utilisation des terres et de la couverture terrestre ainsi que les lieux principaux de conflits. Les cartes montrent que les principaux conflits se sont produits le long de frontières poreuses où les champs agricoles empiétaient. Une démarcation claire de la frontière de la zone pastorale pourrait préserver l'accès exclusif des éleveurs aux ressources en son sein. Cependant, le désir des éleveurs de clarifier les frontières et de maintenir simultanément une certaine forme de flexibilité pour l'accès aux ressources en dehors de la zone souligne la complémentarité entre les deux processus, à savoir la démarcation des frontières et la mobilité pastorale. Cette complémentarité est encore plus importante en période de pénurie de ressources et de conflits. Le mystère autour des cartes contribue à entretenir une ambiguïté qui est essentielle pour atteindre simultanément les deux objectifs.

Mots clés : SIG, changement d'utilisation du sol et la couverture terrestre, conflits frontaliers entre éleveurs et agriculteurs, mobilité pastorale, Sahel, Burkina Faso

Resumen

La reubicación de pastores en zonas de pastoreo es usualmente criticada por impedir la movilidad para el pastoreo, que resulta esencial para la subsistencia. Integramos narrativas de conflictos y cambios medioambientales con mapas para demostrar la complementariedad entre los patrones de movilidad para el pastoreo -fronteras porosas- y demarcación fronteriza -fronteras rígidas. Utilizamos evidencia de la zona pastoral de Sondré-Est, en el sur de Burkina Faso, donde los pastores fueron voluntariamente reubicados cerca de comunidades agrícolas luego de las sequías de la década de 1970. Sin embargo, con el tiempo, los agricultores invadieron los límites de la zona de pastoreo y estas tierras se deterioraron. Esto incrementó los conflictos por el uso de suelo. Las tensiones se agudizaron con el hecho de que estas poblaciones mantuvieron los mapas como un secreto dentro de la comunidad. Hicimos una recreación de los límites administrativos de la zona de pastoreo para hacer un mapa de los puntos con cambios y conflictos en cuanto al uso de suelo y la cobertura del terreno. Los mapas revelan que los conflictos se presentaron a lo largo de las fronteras porosas, donde los campos agrícolas invadieron el terreno. Los pastores pidieron se hiciera una demarcación clara de los límites de la zona de pastoreo para así, preservar el acceso exclusivo a los recursos dentro de esta. Al mismo tiempo, ellos pidieron se mantuviera un acceso compartido al resto de los recursos al exterior de la zona de pastoreo. Su deseo, tanto por claridad en las fronteras como por cierta flexibilidad, remarca la complementariedad entre ambos procesos, especialmente en tiempos de escasez de recursos y de conflictos por el uso de suelo. El misterio alrededor de los mapas ayuda a mantener una ambigüedad que resulta clave para perseguir ambos objetivos.

Palabras clave: GIS, cambios de uso de suelo y cobertura del terreno, conflictos limítrofes entre pastores y agricultores, patrones de movilidad para el pastoreo, Sahel, Burkina Faso.

1. Introduction

Sedentarization and land privatization have reduced pastoral mobility – known as an essential risk-reduction strategy in the Sahel of West Africa (Turner 2011). Much previous research has focused on the negative impact of sedentarization and border rigidity on livelihood systems that rely heavily on mobility in the Sahel. Little is known, however, about the complementary role between mobility and border formation in securing resource access in resettlement areas in times of declining resources.

The objectives of this article are to:

1) Analyze border demarcation (i.e., physically marking territory) as a process – not an end goal – toward securing natural resources in times of resource scarcity.
2) Examine the complementarity relationship between pastoral mobility and border formation.

We integrate herders' and farmers' narratives of conflict and environmental change with secondary GIS data on land-use and land-cover (LULC) change to investigate how environmental changes fuel land-use conflicts

that create a need for border formation to protect livelihood resources – especially in communities where mobility is key.

First, we review pastoral mobility studies within political ecology that explain how mobility and porous borders are essential for Sahelian herders living in marginal settings. **Second**, we explore the history of sedentarization and border demarcation in southern Burkina Faso. **Third**, we examine contemporary linkages among sedentarization, border demarcation and land-use conflicts. **Last**, we analyze how border demarcation is a process that complements pastoral mobility in the twenty-first century. We use the Sondré-Est Pastoral Zone in southern Burkina Faso as a case study to document these complex human-environment dynamics.

Sondré-Est is a unique case, where a farming community donated land on which pastoralists were voluntarily resettled and given resources for raising livestock after the devastating droughts of the 1970s. Over time, however, farmers have encroached into the borders of the pastoral zone and surrounding savanna pasture has declined. The conversion of savanna to agriculture eventually engendered conflict between herders and farmers. The fact that no one in either the agricultural or pastoralist communities has a copy of the most recent map of the pastoral zone or knows where the actual boundaries lie, exacerbates these tensions. Mossi farmers and Fulβe herders[2] agree there is a map of the area showing the actual borders. Maps were drawn by governmental and non-governmental agencies at the time the zone was gazetted in the 1970s. Yet, both the farmers' and herders' communities of Sondré-Est – including the extension agent representing the Ministry of Livestock in the pastoral zone to whom our contact at the Ministry referred us – claimed not to have any physical map of the area.

We use participatory mapping to re-create maps to visualize the extent of environmental changes and pinpoint hot spots of acute conflict. We detect substantial LULC change that corroborates herders' and farmers' perceptions of agricultural expansion and declining savanna. We also find that conflict areas are located in particular places along borders where agricultural and pastoral activities overlap, especially around key water points. Agricultural fields encroach on the borders with Sondré-Est – promoting a decline in pasture resources and water access. Therefore, we propose that simultaneously demanding both boundary demarcation and mobility is not counterproductive, but complementary.

2. The complementarity between border formation and pastoral mobility

Pastoral mobility and the importance of porous and ambiguous borders

Previous studies have looked at mobility and border formation as contradictory to one another. Pastoral mobility studies have shown the importance of mobility for pastoral livelihoods in the Sahel. Historically, customary institutions in West Africa have ensured that boundaries are porous to allow mobility as a strategy to minimize the impact of drought on rural livelihoods. The Fulβe herders are traditionally known for their mobile livelihoods (Ellis and Galvin 1994; Brottem *et al.* 2014). Livestock mobility has been an adaptive tool with socioeconomic benefits (e.g., better access to markets and nutritious fodder at minimal labor and cost) and environmental ones (e.g., mitigates the effects of droughts, and allowing use of underused pasture in remote areas) (Niamir-Fuller 1999). The ambiguity of borders and the absence of maps in places where people rely on mobility provides an opportunity to claim land-use rights (Bassett 1988; Moritz 2006; Turner and Moumouni 2019). For instance, Mossi farmers – who are involved in extensive agriculture and circular labor migration – rely strongly on customary tenure regimes involving permeable borders (Breusers 2001; Cordell, Gregory and Piché 1996). Migrant farmers who leave a plot of land can be assured access upon returning. The vagueness and porosity of boundaries makes it difficult to apply formal tenure systems, leading to the 'paradox of pastoral tenure', namely how to secure communal tenure while sustaining spatial and social flexibility (see Fernandez-Gimenez 2002).

[2] The Fulβe are one of the largest pastoral groups in West Africa and the Mossi are the largest ethnic group in Burkina Faso.

The push for sedentarization and border demarcation

The formation of new boundaries – led by state officials – is criticized for hindering pastoral mobility. Since the 1980s, Burkina Faso's reform policies to improve land access and tenure security for vulnerable landless groups (e.g., herders, migrants) have imposed rigid spatial and social boundaries. The 1984 *Réorganisation Agraire et Foncière* (RAF) reform increased the power of the state and reduced the power of traditional chiefs in granting land to migrants (République du Burkina Faso 1984). These changes to land tenure regulations, passed by the socialist government of Thomas Sankara, allowed the state to set aside land for national projects such as the Volta River valleys resettlement program, referred to as *Programme d'Aménagements des Vallées de la Volta* or AVV (McMillan 1995). The AVV was an extensive development program in river valleys that were sparsely populated because of onchocerciasis (river blindness). The World Health Organization (2015) defines onchocerciasis as a parasitic disease caused by the repeated bites of a fly that spreads Onchocerca volvulus, a filarial worm. Following the droughts of the 1970s, the AVV developed these areas to encourage voluntary resettlement of farmers and herders from densely populated and drier provinces in the north toward less densely populated and more fertile regions in the south (McMillan, Nana and Savadogo 1992).

The government created pastoral zones aimed to open herders' access to land to develop the livestock sector – vulnerable to droughts but key for the national economy – and to reduce livestock mobility, a phenomenon that across Burkina Faso has led to countless farmer-herder conflicts, and that complicates governance and development assistance to mobile communities. In Sondré-Est, the government received funding and technical support from the Netherlands to create a discrete pastoral zone. Yet, until the 1990s and early 2000s, most herders were still involved in seasonal migration, depending on the size of their herds and the extent of drought (N'Doh 1992; Nébié 2005). In the first stage following the cereal harvest, they moved livestock short distances into surrounding agricultural villages to graze on crop residues; a standard practice in the region. Some herders moved livestock daily, others settled temporarily in nearby villages. In the second phase occurring in the second half of the dry season, most herders moved south to other regions once crop residues and natural grasslands were locally depleted. Some herders did not migrate at all, due to small herd size or a lack of labor. We did not find a recent study that examines pastoral mobility patterns in Sondré-Est after 2005, right before the Ministry of Livestock published the most recent regulatory document of the Pastoral Zone known as *Cahier de Charges* in 2006 (see MRA-BF 2006).

In Burkina Faso, human and livestock migrations from northern areas to resettle in the south have stimulated substantial land degradation in southern areas over time (Nébié and West 2019). Sedentarization is linked with population increase and more intensive land-use and therefore land-cover change (de Bruijn and van Dijk 1999). These changes result from land-cover being broken into dispersed fragments for diverse purposes (Galvin 2009). Fragmentation prevents flexible access to grazing land (Moritz *et al.* 2013, Turner *et al.* 2016). Competing land-use practices and livelihood strategies, rather than ethnicity alone, is the primary cause of farmer-herder conflicts (Ejigu 2009; Breusers, Nederlof and van Rheenen 1998). Competition occurs, for example, when agricultural fields and grazing areas use the same land. For instance, at the end of the rainy season, this competition occurs as farmers try to harvest crops while nearby herders graze their herds on the surrounding stubble. Fields and grains are ready to harvest at different times and animals have to be carefully watched so that they do not enter fields with mature crops. At the beginning of the rainy season, conflicts also occur when Mossi farmers clear savanna and forest to make new agricultural fields while herders preserve savanna to secure grazing lands. This brings herders and farmers into close proximity with one another and amplifies their competing use of the same land. At the same time, however, the manure left by grazing animals can add organic matter to fields. Thus, the relationship between farmers and herders is characterized by both "conflict and symbiosis" (Breusers *et al.* 1998).

Sedentarization, border demarcation and land-use conflicts

Territory delineation and mapping – led by the government – has set rigid boundaries in rural areas where customary systems continue to sustain flexibility. The state defines the boundaries of the pastoral zone

in articles 4 and 5 of the regulatory *Cahier de Charges* (see MRA-BF 2006). But these boundaries are disputed because of the clash between state and kin-based systems of right to land (Nébié 2020). Differently from state-based systems, rural territories are complex landscapes of diverse property rights where land tenure is a political process shaped by settlement history and ongoing re-interpretation (Bassett and Crummey 1993; Lentz 2013; Reenberg and Lund 1998). In Sondré-Est, as per customary land law, the chief of the Mossi village of Sondré, located west of the Pastoral Zone (see Figure 1), offered a portion of his chiefdom to the government to resettle Fulβe herders. This was done orally and included no physical map.

The state's efforts to map rigid borders on traditionally boundless places – with the goal to secure land for the landless – strains traditional negotiation relations between landowners (i.e., autochthons, farmers) and users (i.e., migrants, herders). Creating pastoral zones has created friction between pastoralism and agriculture, which are complementary activities (Robert 2010). Farmers – usually natives in areas to which Fulβe move – define Fulβe migrants as 'strangers' because of their weaker attachment to local lands (Hagberg 2001). Mobile pastoralists – who traverse different villages with livestock in search of pasture and water – have long relied on host-stranger relationships with native groups to negotiate access to water, grass and passage (Brottem 2014). The Fulβe – whom the government resettled in delineated pastoral zones – no longer accept this 'strangerhood' which precipitates disputes over land. As users challenge customary tenure systems, traditional land-owners contest changes that affect their authority. This situation fuels conflicts.

The convergence of farmers' and herders' livelihoods increases land-use competition, but also potentially strengthens cooperation and prevents conflicts (Turner *et al.* 2011). Pastoralists diversifying into farming hire other herders to migrate with some of their livestock. These same households remain in Sondré-Est with a smaller herd in order to tend their fields. As the amount of cropped land within the pastoral zone increases beyond a certain level, livestock become more mobile due to insufficient pasture and the need to avoid crop damage. Relocating livestock to other regions shifts neighboring farmers' anger away from Fulβe within Sondré-Est and toward non-local herders who bring in animals from far away.

Land-use conflicts are complicated by the influx of additional – and more powerful – foreign stakeholders such as mining companies. In 2016, Sondré-Est leaders forced out a mining company that came with official maps and a license for mineral exploration from their pastoral zone (Somé and Camara 2016). This delegation was led by the Provincial Director in Charge of Livestock to negotiate with the residents of Sondré-Est. The Provincial Department of Livestock oversees the development of the livestock sector in the region and played a primary role in the resettlement of herders into Sondré-Est. The cooperation between this department's officials and the mining company poses a grave threat to herders in Sondré-Est. The herders now rely on their local leaders – in the committee leading the management of natural resources in Sondré-Est, known as *Comité de Gestion* (COGES) – to secure their borders and resources. COGES is an initiative of the government that promotes local participatory management of natural resources and border security.

Border demarcation and pastoral mobility as complementary processes

Rather than conceptualizing border security and mobility as permanent solutions to land-use conflicts and resource access, we view them as complementary processes. Turner *et al.* (2016) have demonstrated that transhumance corridor networks (i.e., interlinked system of paths that connect physical and fixed features such as encampment sites, water points and corridors to facilitate access to key pastoral services such as pasture, water, markets, and security) can be a middle ground between flexible access to resources – through livestock mobility – and spatially-fixed physically features protected from competing land use. We examine how a similar hybrid system – involving livestock mobility and border clarification – sustains livelihoods in a pastoral zone where borders are kept ambiguous. We use maps and narratives to explore how environmental changes and declining resource availability call for border demarcation to complement pastoral mobility in an era when mobility is hindered by diverse social, political, economic and environmental challenges. Pastoral mobility and border demarcation are changing processes aiming to protect users' rights and their ability to make flexible choices (i.e., sedentarism and/or mobility) in the future (Moritz *et al.* 2013). In these processes, maps can serve as political tools and symbols of power (Bauer 2009). This is particularly true in places where the prevalence of oral tradition and the absence of physical maps stimulate competition and land-use conflicts. Some

indigenous groups have used geographic information systems (GIS) to re-write maps and claim historical territories (Bryan 2011; Poole 1995; Weiner and Harris 2003). Used for analytical purposes, as is the case in this study, maps can help visualize the extent of LULC changes and identify conflict hot spots (Brown and Raymond 2014).

3. Study site

The Sondré-Est Pastoral Zone is located at the north-east corner of Zoundwéogo Province. Sondré-Est lies between the 11°50' and 11°57' latitude north and meridians 0°53' and 1°03' of longitude west and is limited in the east by the Nakambé River, and in the south by the Kaïbo-Nord V2 Village (MRA-BF 2006: 5). Sondré-Est is about 30 km from Manga, the administrative capital of both Zoundwéogo Province and the Center-South Region (see Figure 1). Sondré-Est consists of 16,460 ha with 15% of land reserved for housing and 85% for grazing. It also hosts a training and business center of 1,160 ha. The site receives about 880-900 mm of rainfall annually with a five-month rainy season that lasts from May to October.

Savanna is the major land-cover type in the pastoral zone and herders rely on savanna grassland to graze livestock. In Kaïbo-Nord V2 and Sondré – where the majority of the population engages in agriculture – the most dominant land-use type is agriculture. Sondré-Est is divided into four residential and grazing areas – with no clear demarcation among them – known as 'sectors.' While the two neighboring sectors of Sectors 2 and 3 share natural resources and infrastructure, other sectors (Sectors 1 and 4) operate much more independently. Key resources in the pastoral zone include pastures, forest products and infrastructure such as dams, pumps and vaccination parks.

In each sector of Sondré-Est, residents are related through kinship and maintain strong linkages to their villages of origin. Under the Sondré-Est project, most herders came in from other areas of Burkina Faso listed in Table 1.

Local names	French names	Village of residence (province)	Province of origin	Approximate time of arrival
Moossé	Mossi	Sondré (Zoundwéogo)	Zoundwéogo	Autochthons
		AVV area (Zoundwéogo)	Zoundwéogo, Bam, Sanmatenga and Boulgou	1970s
Boussanssé	Bissa[3]	Garango (Boulgou)	Boulgou	Autochthons
		Sinikiéré (Zoundwéogo)	Zoundwéogo	
Yadsé	Yadsé	AVV (Zoundwéogo)	Yatenga, Zondoma	1970s
Silmissi	Fulβe	Sondré-Est (Zoundwéogo)	Zoundwéogo, Bam, Yatenga, Zondoma, Sanmatenga Boulgou, Namentenga, Oubritenga, Ganzourgou and Kadiogo	1980s
		Sondré and AVV (Zoundwéogo)		1970s

Table 1: Ethnic groups in the field site.

[3] The Bissa were not part of the studied group but occupy villages outside the field site.

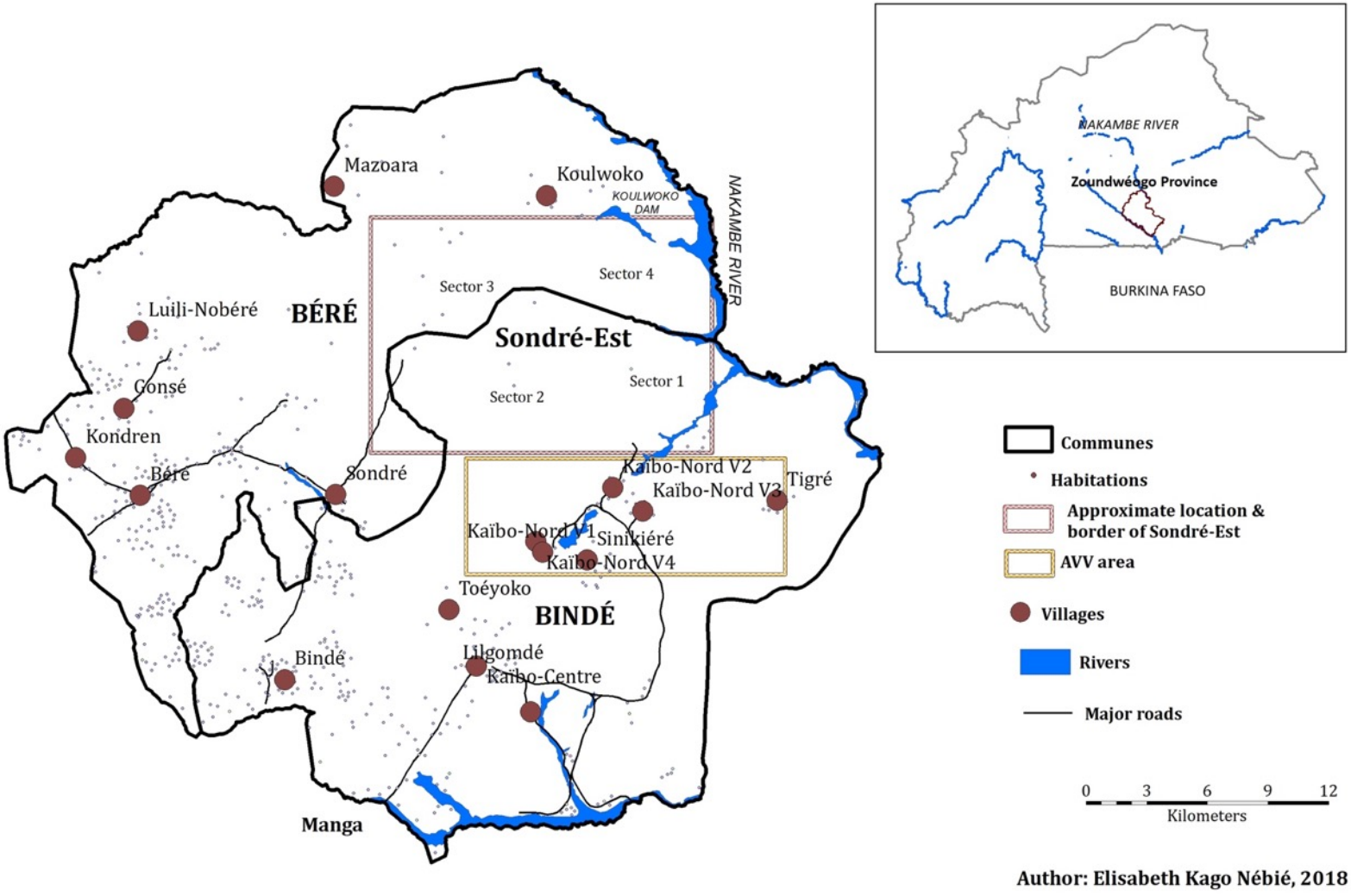

Figure 1: Sondré-Est. Data source: IGB (2015) *Base nationale de données topographiques* (BNDT).

Fulβe herders were targeted and formally invited to resettle in the area, though it was and still is also occupied by other ethnic groups, mainly the Mossi. During the resettlement process, in conformity with customary law in rural areas, land was verbally granted to the government by the chief of the Mossi village of Sondré to resettle herders affected by droughts in the northern part of the country. The name Sondré-Est was given because the portion of land given to resettle the Fulβe was located east of the village of Sondré. Natural barriers such as trees, water points, or gullies were used to demarcate the borders between Sondré-Est, Sondré, and other neighboring villages under the dominion of the chief of Sondré. Some of the first settlers moved because of river blindness being present in their river valleys.

We did not conduct a full census of Sondré-Est due to logistical and financial constraints. Based on spending time there and recent news articles on the pastoral zone from Le Faso.net (Bassolé 2020) and Burkina24Tv (Revelyn 2020), two of the most popular online newspapers in the country, we believe that there at least 8,500 pastoralists living in Sondré-Est. Table 2 shows the demographic growth and population density of Zoundwéogo Province between 1996 and 2006. The population doubled in just ten years and the population density increased by 22.3 percent. During fieldwork, the residents of Sondré-Est estimated livestock population to be between 10,000 and 11,000 animals. Livestock includes cattle, sheep, donkeys, and goats.

Census year	**1996**	**2006**
Total population	127,654	245,947
Population density (hab./km^2)	54.7	67.1

Table 2: Demographics of the Zoundwéogo Province. Data source: INSD 2000: 63, 65; 2009: 67, 127.

Mutually beneficial relationships between herders and farmers involve crop-livestock commercial exchanges and cooperation. Examples include: 1) Livestock deposit manure on agricultural fields; 2) Farmers are hired to work herders' fields; and 3) Herders adopt elements of Mossi culture, such as the Mossi language, *Mooré*. Yet, conflicts also happen, especially when farmers encroach the pastoral zone or even grow crops within the zone. There is a "firewall" buffer zone, which was delineated by the state – and supposed to remain untouched – to physically separate agricultural villages from the pastoral zone. This was instituted in order to avoid potential fires on gallery forests or grazing areas as a result of nearby slash-and-burn agriculture practiced by the Mossi.

4. Methods: integrating GIS with local narratives

The first author conducted 20 months of intermittent ethnographic fieldwork in the Sondré-Est Pastoral Zone and its surroundings. Fieldwork was part of the Local Governance and Adapting to Climate Change in Sub-Saharan Africa (LGACC) project, led by the International Livestock Research Institute (ILRI) and the World Agroforestry Center (ICRAF). The LGACC project assessed characteristics of land governance systems to promote the adaptive capacity of agro-pastoral households across sub-Sahara Africa. We documented the link between areas undergoing rapid environmental change and conflicts. For this analysis, we incorporated the spatial data collected during fieldwork (narratives, hand-drawn maps and GPS coordinates) with GIS and remote sensing data. The integration of spatial analysis with ecological fieldwork in this manner offers a powerful complementary lens for understanding local human-environment complex interactions (Turner 2003; West *et al*. 2017). The process allowed us to identify spatially explicit hot spots of farmer-herder conflicts. The following table and section outline the specific data and methods used.

Fieldwork consisted primarily of interviews, focus groups, and participatory maps, which we used to identify and describe points of conflict. GPS data were taken at these points of conflict and mapped using GIS

to visualize and put them into space. GIS helped to spatially locate contentious areas – as described by participants – and to identify other similar areas that narratives suggested but could not be directly accessed due to the terrain. GIS modeling helped overcome the limitation of not being able to conduct comprehensive interviews everywhere in the area (i.e., in all agricultural villages bordering Sondré-Est). Developing a map in a conflict zone can be perceived as a political act which can exacerbate local people's sense of disenfranchisement. In order to mitigate this, we involved both local herders and farmers in estimating the boundaries of Sondré-Est and conflict hot spots from their diverse perspectives. The mapping process, when inclusive, distributes power and offers participants the opportunity to control the process and resulting maps (Bauer 2009). While previous studies have integrated local narratives with GIS maps to understand livestock activities, typically in places where herders migrate seasonally, this study uses similar methods, but to understand border conflicts in a space inhabited by both farmers and herders.

Source	Data used	Spatial resolution	Time frame
14 Focus groups and 46 interviews	Local narratives of encroachment and conflicts	In Sondré-Est, Kaïbo-Nord V2, and Sondré Village	2016
Participatory mapping	Hand-drawn map of Sondré-Est	In Sondré-Est	2016
GPS coordinates and photographs	GPS coordinates and photographs collected at the different borders of Sondré-Est	At northern, southern and western borders of Sondré-Est	2017
IGB-BNTD (IGB 2015)	Vector administrative boundaries (provinces, communes and villages), rivers, roads and dams	1: 200,000	2015
BF-WALULCTS (Tappan *et al.* 2016)	Raster LULC types: Rainfed agriculture, irrigated agriculture, savanna, gallery forest and wetlands/floodplains.	2-kilometer	1975 (just before the creation of the pastoral zone) 2013 (most recent data available)

Table 3: Description of data.

Focus groups and semi-structured interviews

First, we collected narratives. The first author led a total of 46 semi-structured individual interviews and 14 focus groups (266 participants) in Sondré-Est, Kaïbo-Nord V2, and Sondré Village. She also had informal conversations with farmers in Kaïbo-Nord V2 and interviewed former Sondré-Est leaders and government personnel in Ouagadougou and remotely. Some of these focus groups were led with the third author, particularly the ones in farming villages.

Participant profile	Number of individuals	Number of focus groups
Residents from all sectors	58	1
Residents Sector 1	16	1
Residents Sector 2 and 3	39	2
Zone management leaders (*Comité de Gestion* known as COGES and *Koglweogo*, self-defense movement)	34	3
Women (Sector 1)	49	2
Men (Sector 4)	15	1
Women (Sector 4)	12	1
Total	**223**	**11**

Table 4: Herders' focus groups in Sondré-Est.

Participant profile	Number of individuals	Number of focus groups
Kaïbo	3	1
Kaïbo-Nord V2	6	1
Sondré Village	6	1
Total	**12**	**3**

Table 5: Farmers' focus groups in the villages surroundings of Sondré-Est.

Location	Participant profile	Men	Women
Sondré-Est	Herders	32	3
Sondré	Mossi farmers' traditional chief	1	0
Manga	Government and NGO personnel	11	1
Total		**43**	**4**

Table 6: Individual interviews in Sondré-Est and its surroundings.

Narratives identified borders as a key issue and described areas of tension such as water sources. Yet, we did not find a detailed large-scale map of the Sondré-Est Pastoral Zone to geographically contextualize these border issues. A former project official in the area also recalled the existence of aerial photographs and maps created by the French Geographic Institute in partnership with the Geographic Institute of Burkina Faso (IGB) in the 1970s. We found old maps in a previous study (N'Doh 1992) that warned about a potential increase of farmer-herder conflicts if nothing was done to clarify and secure the borders of the pastoral zone. But during fieldwork, we did not find recent maps. Analyzing newer maps was important because the pastoral zone went through a second demarcation led by the government and contested by autochthonous residents (Nébié 2018).

Participatory mapping

Second, we gathered participatory maps – produced in community mapping exercises – to re-create an updated map of the pastoral zone and its boundaries. Other colleagues working under LGACC were involved in this mapping exercise. A group of nine herders hand-drew Figure 2 – a map of Sondré-Est along with key pastoral resources like dams and rivers as well as their perceived borders of the zone. The goal was to obtain finer-scale local knowledge of perceived boundaries of the zone. A hand-drawn map allows participants to directly interact and take full ownership of the mapping process and the final product. The hand-drawn mapping exercise was not conducted with Mossi farmers because the LGACC project has primarily focused on studying the herders of Sondré-Est, rather than farmers. This emphasis on herders leaves out the social component of the farmers but these boundaries were brought up in focus groups with farmers from Kaïbo-Nord V2 and the village of Sondré as well. We used Figure 2 to create a GIS map of Sondré-Est. Figure 2 was imported into ESRI's ArcMap 10.3.1. and digitized to draw the approximate boundaries of Sondré-Est. We used the IGB administrative boundaries of the Bindé and Béré communes as a base map to georeference Sondré-Est as the brown dotted lines in the hand-drawn map (Figure 2).

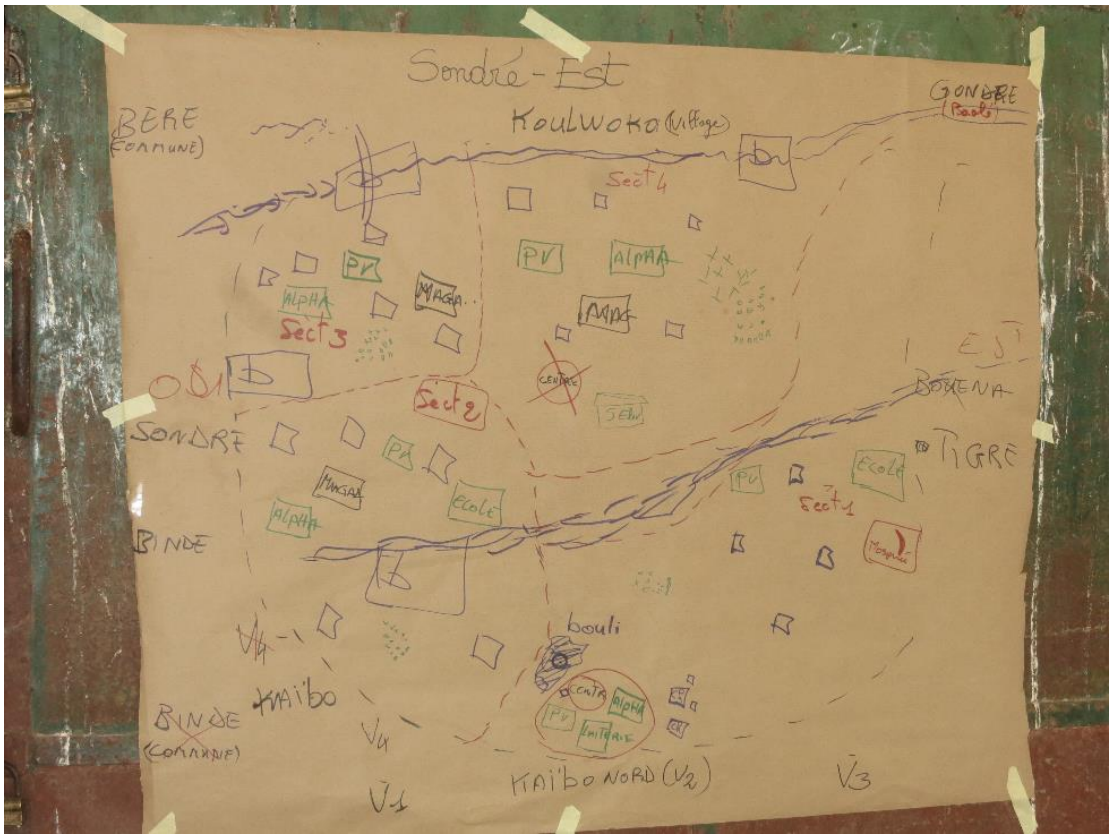

Figure 2: Hand-drawn map of Sondré-Est. The herders represented the pastoral zone as the brown dotted lines.

GPS coordinates and photography

Third, we collected GPS coordinates and photographs of conflict areas. Our field assistant and a leader of the pastoral zone drove around the borders of the pastoral zone on a motorcycle to collect geographic coordinates and photographs of contentious areas along the perceived borders of the pastoral zone. The goal of this exercise was to identify and map most contentious areas in ArcMap. GPS coordinates were collected with

a Garmin eTrex 10 device at the extreme southern, northern and western borders of the zone. We used the photographs (Figures 3, 4 and 5) to visualize the LULC conditions at the border and to discern patterns.

Figure 3: Western border with Sondré Village. On the left are Mossi maize fields in Sondré Village (see Figure 1). On the right are pasture and savanna in Sondré-Est Pastoral Zone.

Figure 4: Southern border with Kaïbo-Nord V2. Note the bridge and pond that form the boundary with Kaïbo-Nord V2.

Figure 5: Northern border with Koulwoko. The left bank indicates the pastoral zone and the right the village of Koulwoko.

The GPS data and photographs we collected also included farmers' perspectives. In Sondré Village, Mossi leaders took us to an area they described as the border with Sondré-Est. We collected GPS data and photographed this place (see Figure 3). In Kaïbo-Nord V2, we recorded GPS coordinates at a gully that farmers had mentioned during the focus group as the present border (see Figure 4). At the border with Koulwoko, we collected GPS data by a gully that drains in to the Koulwoko dam (see Figure 5). The eastern border was inaccessible because of the Nakambé River (White Volta) and the poor condition of the roads. Therefore, we extrapolated from collected GPS data and hand-drawn maps to create borderlines for the eastern borders.

We downloaded the GPS data and exported it into ArcMap. Visualizing the GPS data in ArcMap helped us interpolate between points and derive the borders of the Sondré-Est Pastoral Zone. We digitized these polylines by comparing features in the IGB-BNDT database (i.e., dams, gullies, and roads) with the GPS data, narratives, and participatory map (Figure 2). These same sources were used to identify potential areas of conflict. The red stars (hot spots) displayed in Figure 6 correspond to the most contentious border areas of the zone. We added vector-based hydrological data from the IGB-BNDT data (see Table 3) – only available for 2015 – to the map for visualization purposes.

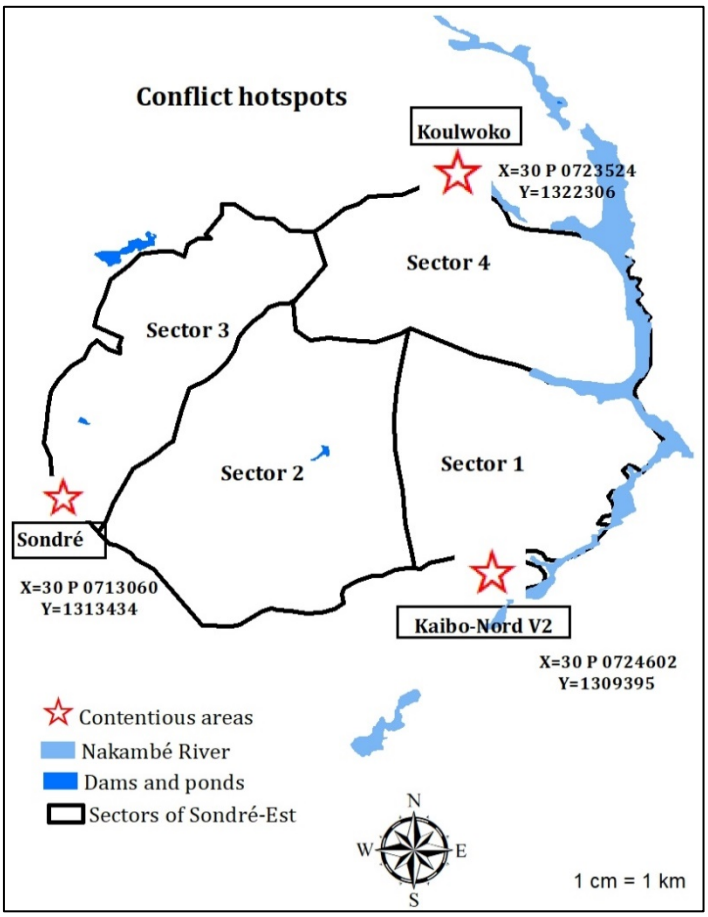

Figure 6: The derived borders of the Sondré-Est Pastoral Zone, and conflict hot spots derived from field research.

GIS and remote sensing data

Last, we used GIS data (i.e., towns, villages, settlements, rivers) and remote sensing data (i.e., land-use and land-cover rasters) to visualize LULC changes. The GIS data is from the Burkinabè National Topographic Dataset (IGB-BNTD) of the Geographic Institute of Burkina (IGB) (IGB 2015). The IGB-BNTD provides country-wide data on administrative boundaries, hydrology, roads and infrastructure –among other features– at a spatial scale of 1:200,000 (IGB 2015). We also used the raster West Africa Land-use and Land Cover Time Series dataset of Burkina Faso (BF-WALULCTS) (Tappan *et al.* 2016). Remote sensing specialists of West Africa collected and analyzed the BF-WALULCTS dataset as part of a comprehensive satellite data archive to map LULC trends in time and space across West Africa. The WALULCTS project uses coarse 2-km resolution data to inform national and regional decision-makers on land resource changes and trends across West Africa. We used the raster BF-WALULCTS data for 1975 and 2013 – overlaid on the boundaries of the derived Sondré-Est Pastoral Zone (Figure 2) – to display LULC changes (see Figure 8 below). We processed the LULC data in ArcMap 10.3.1; projected it to WGS 1984 to match the IGB projection; and clipped it to the boundaries of Sondré-Est, with a buffer that includes villages sharing borders with the pastoral zone.

5. Results

Narratives - Fulβe views

The herders viewed their life in the pastoral zone as comparatively better than that of other pastoralists outside the zone. One of them stated:

> Herders living in the pastoral zone suffer less than those living outside of the zone. Most of these external herders use water points that are very close to farming fields. As soon as cattle leave the water point, it heads directly into an agricultural field, creating conflicts with farmers… Here, in the pastoral zone, we are lucky because we have plenty of space for livestock mobility. We also have key pastoral infrastructure, subsidies and training to help us survive in one place with fewer livestock. (**L – Sondré-Est, 10/23/2016**)

But life in the pastoral zone has re-shaped their customary ways of herding and added new activities into their daily lives. Very few herders are still involved in long distance seasonal migration. They still move livestock, but over much shorter distances. Herders keep fewer livestock in Sondré-Est to be able to access pasture and water inside the pastoral zone and at a short distance (approximately 2 kilometers) from their settlement. At the end of the rainy season, they take animals daily out of the pastoral zone to nearby agricultural villages (Sondré and AVV villages) to feed on crop residues while also leaving manure to fertilize fields. Some herders stay for a longer period of time in these surrounding villages, especially when they are invited by farmers to help manure their fields. Extension agents from the Ministry of Livestock and non-governmental organizations also train the herders to grow and conserve dual-purpose crops for their human and livestock subsistence. They also train herders to include subsidized industrial feed and supplements in their livestock diet during the dry season when there is less pasture.

Women and children also have new responsibilities in herd management as men get increasingly involved in subsistence crop and fodder agriculture. In the dry season, small ruminants wander in the pastoral zone without surveillance while young men (10 to 20 years old) herd cattle to nearby water points during the day. In contrast, during the rainy season, cattle are taken out for night grazing (between 10PM- 4AM) by adult and/or young men, while women and children (5 to 10 years old) keep small ruminants away from subsistence crop and fodder fields during the day. Night grazing helps minimize tensions with farmers and allows livestock to benefit from nutritious grass and water, away from the sun. When, however, livestock destroy gardens or farming fields at night and farmers do not know who to blame, they become resentful against the entire herding community of the Sondré-Est Pastoral Zone. The herders, for their part, complained about Mossi encroachment and farming near key water points. One herder explained that: "Three sides of Sondré-Est are surrounded by water. Thus, farmers often impede on areas of the zone that they can cross. This happens partially at the southern and at the western borders" (**KS – Sondré-Est, 02/24/2016**). Another herder added that tensions also happened when farmers gardened near major water points. He clarified that:

> Farmers garden near the Nakambé River and the dam of Koulwoko; our herds also drink there. The farmers produce up to the borders of the dam. They are too close to where livestock water. When animals drink and see crops nearby, they end up grazing on farmers' fields. Then, farmers capture them. (**AS – Sondré-Est, 02/24/2016**)

In 2016, during fieldwork, community leaders in Sondré-Est identified the disputed borders issue as a major challenge in their adaptation to sedentary life and to environmental changes. One leader of the pastoral zone stated that "the border issue is our daily nightmare and its resolution is an emergency" (**DU – Sondré-Est, 09/14/2016**). The Fulβe – who Mossi farmers view as recent migrants – claim ownership of resources in the pastoral zone based on their legal rights accorded by the government when it encouraged them to settle there. The Fulβe wanted the government to clearly delineate the boundaries of the pastoral zone. This would

serve as a precursor to an official framework to claim land rights and prevent cases of encroachment on Sondré-Est. The Fulβe described agricultural encroachment as one of the main drivers of conflict in the area. They perceived their western border with the village of Sondré as the most contentious one, followed by the southern borders with Kaïbo-Nord V2. Tensions, according to herders, stemmed from the fact that rainfed agricultural land and gardens encroached on what herders perceive as reserved grazing and watering areas within the pastoral zone. There were also tensions with northern and eastern counterparts. These tensions, however, were not considered as crucial as those with communities at the western and southern borders. This difference was due to the presence of the natural barriers of the Koulwoko dam and the Nakambé River, which separated Sondré-Est from its northern and eastern neighbors.

But there was no fine-scale map to identify conflict hot spots in space. The herders of Sondré-Est stated they had seen a map of the pastoral zone, but they did not have this map in their possession. According to them, the map remained with the pastoral extension agent of Sondré-Est, but the extension agent was also unable to find and share it in the midst of brewing border disputes in the area. Extension agents typically live and work in a given village for a fixed period of time and are then sent to work elsewhere. They therefore rotate frequently in-and-out of Sondré-Est and there have been numerous extension agents in the community over time. This constant turnover potentially explains how maps could be lost.

Narratives – Mossi views

In the study area, there are two different Mossi settlement patterns. The Mossi from Sondré Village are autochthons who have lived in the area for multiple generations while the Mossi of Kaïbo-Nord V2 are resettled migrants who were voluntarily brought to the area with state assistance. Both groups accused the Sondré-Est herders of retaining two different maps of the pastoral zone. According to them, herders refused to share them, so as to take full advantage of these maps depending on the situation at hand. One of the maps apparently showed the borders of the zone in 1977 at the beginning of the Sondré-Est project, when the chief of Sondré verbally gave the land to the government to resettle herders. The other map displayed the borders after the second demarcation in 1984, which was a matter that is highly contested by neighboring farming villages. In Kaïbo-Nord V2, a migrant Mossi stated:

> We would like to see the original maps of the AVV and of Sondré-Est to see what the first agreement was and how things were at first when the zone was first created before we agree on the borders. We want to see the maps to know the truth. If we see the real maps, we cannot disagree. We disagree right now because the zone has two maps showing two different borders. Thus, the pastoralists use each map depending on how useful it is for the situation. (**OA – Kaïbo-Nord V2, 09/17/2016**)

The Mossi of Sondré Village – who have lived in the area for generations – argued that the pastoral zone has encroached on their village. They made these claims based on their customary rights to the territory of the pastoral zone, which used to be part of Sondré. They opposed any official demarcation of the pastoral zone as it would decrease their access to resources within the zone and reduce their ability to expand agriculture.

The Mossi listed two major land disputes with the pastoral zone. On the one hand, in the village of Sondré, autochtons claimed fertile off-season gardening land between the dam of Sector 3 and the current border with the village of Sondré. The claimed portion was known as Zorgho, once a very small village known for its humid and fertile land. Gardeners from Sondré Village used to live in Zorgho before the second delineation and even before the dam of Sector 3 was created (see Sector 3 dam in Figure 6). According to some Sondré Village farmers, when their chief gave the land to create the pastoral zone, he did not intend to give away Zorgho – his constituents were already living there. The residents of Zorgho were displaced to Sondré Village and other neighboring communities following the second demarcation of the pastoral zone led by the Ministry of Livestock without consulting customary authorities in Sondré Village. Other accounts from Mossi farmers state that a second delineation of the zone – allegedly conducted by officials from the Provincial Department of Livestock along with the residents of the pastoral zone – without the approval of the chief of

Sondré – had taken away this productive Sondré agricultural land to expand Sector 2 and 3. Sectors 2 and 3 – which share borders with Sondré and Kaïbo-Nord V2 – were strategically located because they had more pasture and a key dam. On the other hand, the border with Kaïbo-Nord V2 is clearly demarcated with a signpost (see Figure 7).

Yet, migrant Mossi complain about the second delineation of the pastoral zone that reduced the area of Kaïbo-Nord V2. About 52 ha of rainfed agricultural land was taken away by the government. In this second demarcation process, the government placed a new signpost marking the entrance into Sondré-Est which is now further away from the first signpost. One of the farmers said:

> We were not consulted before our agricultural land was taken away … V2 is landlocked and villages all around it have grown. We do not have enough space to expand fields in all directions because there are fields everywhere. It is only north of us that we see empty space with hopes to expand, but unfortunately, this is where Sondré-Est is located at … (**AS – Kaïbo-Nord V2, 09/17/2016**)

The two disputed areas were likewise claimed and valued by herders who dig wells to water their cattle during the dry season. The people of Sondré Village and Kaïbo-Nord V2 claimed that they had not cultivated in these contentious areas since the second demarcation. Farmers argued that they no longer force their way into Sondré-Est, not because they agreed with the border demarcation but rather because:

> We have no other choice. The herders are more powerful and richer than us. They also have stronger connections with government officials compared to us. See how many trucks cross Kaïbo-Nord V2 to go into the pastoral zone! If we dare force our way into the zone, we would get jailed. (**ZI – Kaïbo-Nord V2, 09/17/2016**)

The farmers perceived the creation of the pastoral zone as only benefitting the herders. The farmers explained the fact that they cannot access land in Sondré-Est has reduced their farming space. This has impeded their livelihoods. One of them concluded: "If we knew that life here would become so difficult and that we wouldn't have enough space to farm at some point, we wouldn't have come" **(OS – Kaïbo-Nord V2, 09/17/2016**). After reading guidelines in the *Cahier des Charges*, we understood that the government displaced farmers who encroached on the borders of the pastoral zone to enforce the respect of the firewall between agricultural fields – on which farmers continued to practice slash and burn agriculture – and the savanna inside the pastoral zone (see MRA-BF 2006). While herders also mentioned the firewall, its presence and importance seem unclear to farmers. They believe this demarcation was done against them and to benefit the pastoralists who can still take livestock to graze in the firewall area. Herders are allowed to take livestock in this area because grazing does not create fire hazards as compared to slash-and-burn agriculture.

Maps

We sought to visualize changing land-use dynamics described by participants by mapping LULC data between 1975 and 2013. The WALULCT data show conditions in 1975 before Sondré-Est was created and 2013 near the time of fieldwork. The LULC changes in Figure 8 indicate that agriculture has been expanding around and into Sondré-Est between 1975 and 2013. Encroachment is apparent at the southern border with Kaïbo-Nord V2, the western boundary with Sondré, and the northern limit with Koulwoko.

Encroachment is especially apparent at the border between the village of Sondré and Sector 3 of Sondré-Est up to the border with Sector 2. The decreased savanna on the maps validates herders' perceptions that "grass is now scarcer" within the field site. Unfortunately, one of the limitations of our analysis is that the coarse resolution of the LULC data (2-km^2) may have exaggerated the observed changes. Nonetheless, it shows the general spatial and temporal trends – i.e., agriculture expanding and savanna decreasing over time.

Figure 7: The signpost of Sondré-Est at the border with Kaïbo-Nord V2.

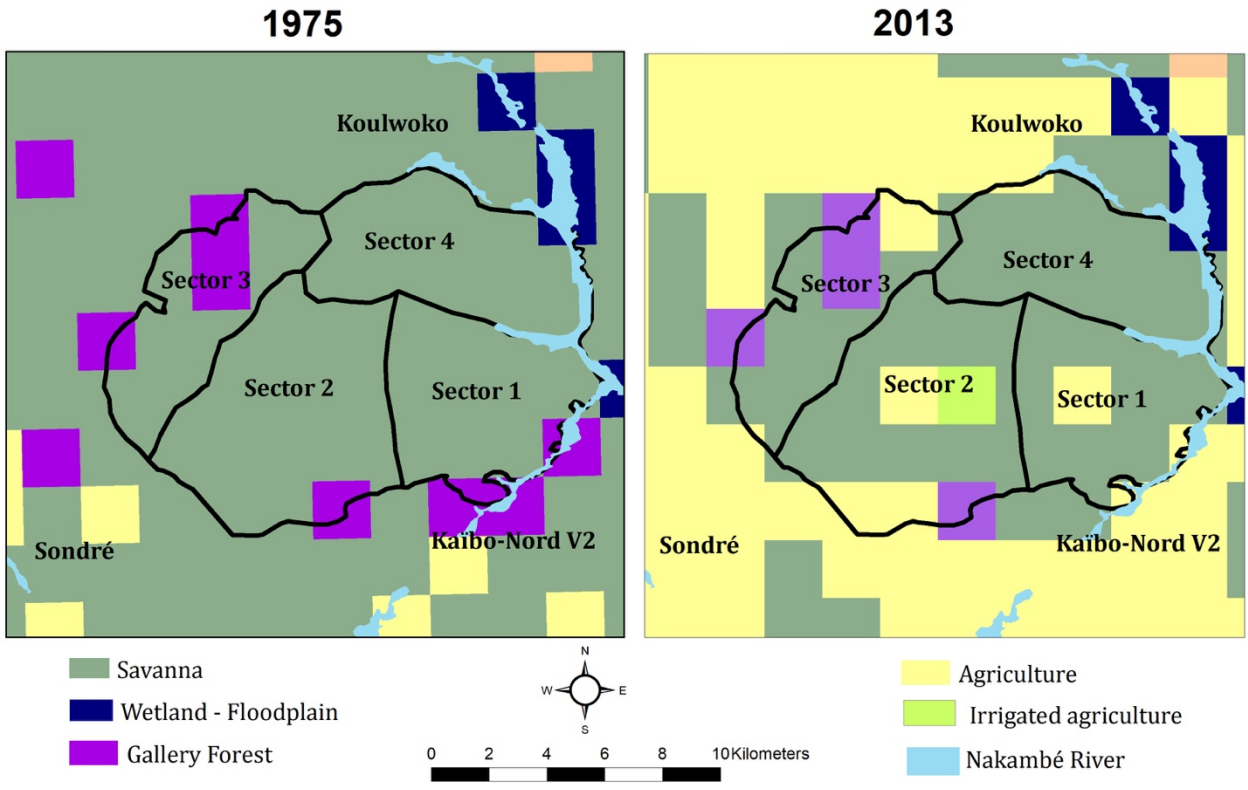

Figure 8: LULC in the Sondré-Est area in 1975 and 2013.

A cross-checked analysis of the contentious areas' photographs (Figures 3, 4, 5) and LULC maps (Figure 8) illustrated that contentious places corresponded to areas where agriculture replaced savanna *within* the pastoral zone. Less contentious borders were demarcated by natural barriers such as water points (Figure 5: east and north of the zone). In contrast, the most problematic borders had insignificant natural barriers or lack them entirely (Figures 3 and 4 – western and southern borders). Figure 3 indicated that the border with Sondré Village, perceived as the most contentious one, was only delineated by a minor dirt path. This dirt path served as a shortcut for people in sectors 2 and 3 of Sondré-Est and those of Sondré Village going south, especially to Kaïbo-Nord V2. Figure 4 displayed a gully that separated the pastoral zone from Kaïbo-Nord V2. A small bridge on this gully served as the main road connecting the pastoral zone with Kaïbo-Nord V2 and urban centers to the south. In contrast, Figure 5 showed the border with Koulwoko, separated by a river that is difficult to cross. Many perceived this border as less contentious because it consists of a physical barrier.

6. Discussion

Border demarcation is key in times of encroachment, decreased mobility and resource scarcity

Border demarcation is a survival strategy for sedentarized pastoralists when mobility is restricted and where agricultural fields encroach on grazing land. In the midst of decreased grazing areas in their surroundings, clarifying borders can help reduce conflicts in the times of increased competition and tensions with farmers. Encroachment, due to lack of border clarity, threatens the availability of increasingly scarce natural resources that are essential for pastoralism. We used maps and photographs to identify the extent of environmental changes and visually identify conflict hot spots. LULC change maps show the extensive conversion of savanna into agricultural land in surrounding farming villages compared to very little change within the pastoral zone. These LULC changes resulted from different livelihood strategies observed inside and outside Sondré-Est. One of the major limitations was the coarse resolution of the LULC data. The 2-km^2 coarse resolution of the BF-WALULCTS dataset might exaggerate LULC changes displayed on the maps. Though future studies can address these limitations, we created maps to highlight the overall temporal and spatial changes in the field site, namely the conversion of savanna to agriculture over time. The photos of these areas show that they correspond to places without clear delineation, whether through natural (river or gully) or man-made (signpost) barriers.

Ambiguous barriers and land encroachment facilitated easy access, but areas with physical barriers (i.e., signposts) discouraged such behavior. Borders only separated with ambiguous barriers were more contentious compared to borders demarcated with clear barriers. The spatially explicit maps we produced revealed that conflicts occur in very particular places along the border where key water, grazing and agricultural resources are located. Local narratives define conflict hot spots as usually located around water points or places where farmland encroaches on grazing areas. These areas include key water points and borders where land-use practices spatially overlapped (i.e., herders preserved savanna to secure pastures, while farmers cleared savanna and forest to create new farms or gardens). During the rainy season, Fulβe herders cultivate, but on smaller fields well within the interior of Sondré-Est.

Herders perceive Mossi mobility (encroachment) across the border of the pastoral zone as a threat to their survival in times of declining forage. Herders now assert stronger claims to their land to sustain their livelihoods as they become increasingly sedentary in the times of climate change and land tenure reforms. Outside the pastoral zone, Mossi farmers perceive Sondré-Est's land as an opportunity to expand agricultural land. Mossi farmers cannot expand south of their village because it is home to yet other farmers who are also looking for space. Based on false notions of pastures being 'empty' and 'unused' land, many farmers perceive expanding north toward the pastoral zone as their only option. Mossi farmers, as argued by Breusers (2001) sustain their livelihoods through mobility represented by their shifting agriculture, even though this contradicts the original AVV principles that required settlers to adopt intensive agriculture in one specific location.

The conversion of savanna into agricultural fields and the idea that there is no more space to expand fields southwards is reminiscent of the situation in northern Burkina Faso thirty years ago when both Mossi farmers and Fulβe herders were resettled. In the name of traditional 'stranger' and 'host' relationship, there is

the expectation that herders return the favor of land access to their 'host.' Customary interdependence between herders and farmers is somehow sustained – in the midst of tensions – in commercial exchanges and when farmers open up their fields to livestock coming from the pastoral zone to help fertilize them. At the same time, however, the border issue creates tensions that complicate these interactions.

Pastoral mobility and border formation are complementary processes

Drawing on pastoral mobility studies that emphasized the importance of livestock mobility for resource access in the Sahel, we propose that calls for a clear border demarcation of Sondré-Est is also a process toward better access to pastoral resources, particularly in times of sedentarization and resource crisis. While there is a trade-off between mobility and border formation, herders requesting borders with signposts does not mean that they no longer value mobility. Being able to access a diversity of grazing and water areas through mobility is key.

The creation of a pastoral zone has decreased human and animal mobility. Yet, livestock are still mobile, but in a different way. Part of the livestock are now herded daily to grazing and watering areas, but at a shorter distance, within the pastoral zone. Livestock diets inside the pastoral zone are supplemented with industrial feed to compensate for fodder scarcity when livestock stays in the pastoral zone in the dry season. After a few observations and informal conversations with herders, we also discovered that many of them owned satellite herds that they entrusted to their acquaintances in other regions of the country to compensate for increased grass scarcity in their settlements and their inability to purchase industrial feed for their entire herd. This form of mobility allows herders to only keep a few animals that they can care for by staying in the pastoral zone. The fact that herders desire both border demarcation and some form of mobility underscores that these processes are complementary. Their main goal is to preserve exclusive access to resources within the Sondré-Est Pastoral Zone while also maintaining shared access to other resources outside of it.

The creation of the pastoral zone has helped to preserve grassland within its borders. The contrast between the dramatic expansion of agricultural land outside the pastoral and the stability inside the pastoral zone over time confirms the impact that border formation has had on shaping the environment. In this process, access to resources in Sondré-Est is determined by residence status and livelihood system. This excludes Mossi farmers (migrants and autochthons) living in the surroundings of the pastoral zone. Native farmers perceive herders' request for a clear demarcation of the borders of Sondré-Est as a 'betrayal' and a challenge to customary arrangements, especially in areas that autochthons also claim as part of their territory.

The absence of a map complicates formal tenure systems and state intervention and serves as a basis for both parties to claim access to resources essential for their survival. Without a clear official boundary, farmers and herders have to rely on customary negotiation systems, which value different forms of mobility, rather than formal state-sanctioned forms that are less flexible and possibly more deleterious to farmers and herders alike. The creation of COGES offers an opportunity to re-activate such negotiations, but in a different way. Autochthons now have to ask migrants for permission in order to use land and water in the pastoral zone. Even though this arrangement does not solve the border issue, it reduces conflicts and keeps borders porous without further involving the government and without reference to maps. The fact that COGES decided to appease conflicts without trying to involve the government further, or to solve the border issue permanently, brings us back to the importance of keeping borders ambiguous. Having the map that delineated these boundaries would help but could also harm, because maps and signposts would negatively impact livelihoods for both groups – who increasingly rely on mobility and porous borders.

While herders and farmers can negotiate access to resources due to the complementary nature of their livelihood systems and the fact that both systems value mobility, the relationship between herders and mining companies is new and counterproductive. Mining companies rely on maps and often do not appreciate the mechanisms of rural mobility. Even though mining could offer off-farm job opportunities, the expansion of mining sites would further reduce grazing and agricultural land, leading to a displacement of herders out of the pastoral zone. In contrast to agricultural encroachment that happens in particular areas and leads farmers and herders to re-negotiate access to resources, mining could end both pastoralism and agriculture altogether in the area.

7. Conclusion

Competition for land has now become the 'new normal' in many rural areas where governments and development projects encourage sedentary lifestyles, intensive agriculture and herding, and private property. The ecological changes that we mapped and discussed in this article are the product of the unforeseen consequences of development initiatives undertaken more than four decades ago. In Burkina Faso, pastoral zones were established in unoccupied areas near farming communities, as shown on the 1975 LULC map. At the time, they were far away from established villages. There were few tensions or conflicts in the 1970-1980s when the area was only sparsely populated and there were less livestock.

In the twenty-first century, demographic and livestock pressures associated with the saturation of space and resource use have increased tensions. Mossi agricultural fields and gardens, which are larger in size and number, are expanding up to the borders with Sondré-Est. This process is evident in Figure 8, which shows the dramatic conversion of savanna into agricultural land surrounding Sondré-Est, and encroachment at specific locations along its borders. Mossi land-use practices, namely extensive agriculture, are characterized by the expansion of fields into new areas. When the government created the AVV and pastoral zone, Mossi farmers raised few objections because they did not farm in those areas and had no immediate plans of expanding into any. As the population increased and farming expanded, their fields nevertheless began to encroach on the pastoral zone. The Sondré-Est project and the AVV program did not anticipate that in the long-term, the empty zones where they resettled herders would become farming areas. They also did not foresee that Sondré-Est land would be coveted by mining companies.

We have demonstrated how the creation of pastoral zones – shaped by larger ecological, political and economic changes – stimulates local environmental changes (cropland expansion and decreased grazing areas) that fuel disputes over scarce natural resources. We created LULC change maps to show how the dramatic conversion of savanna to agriculture has decreased the space available for grazing, especially outside of the pastoral zone. This pushes communities – for whom mobility has been documented as a successful livelihood strategy in marginal environments – to request a clear demarcation of borders. Delineating pastoral infrastructure, especially with maps, is often believed to provide landless communities with more legitimacy and to protect their access to resources.

This case study shows that herders are mixing both mobility and borders to respond to resource scarcity and issues of access in ways that are complementary. Both mobile ways of living or securing borders with natural or human-made barriers are used as a process toward resource access, which is the end goal. One strategy does not automatically preclude the other. The fact that no one wanted to share an actual copy of the map showing the exact borders of the pastoral zone at its creation confirms the advantage of keeping the borders ambiguous. In this process, keeping maps as community secrets serves to sustain claims over a portion of the border. It also enables both groups to preserve mobility and preserve the traditional negotiation relations that link them as demonstrated by COGES.

At the same time, not solving the border issue could make Sondré-Est and its surroundings more vulnerable to foreign actors, such as mining companies, who are targeting the area for mineral exploitation. As a herder-led management committee, COGES, alone, will have a hard time addressing additional land-related challenges, such as mining claims, that go beyond the unsolved border issue. Without the state's support, it may be time for herders to start joining forces with local farmers in the area to avoid additional stress on deteriorating natural resources.

References

Bassett, T.J. and D.E. Crummey (eds.). 1993. *Land in African agrarian systems.* Madison, WI: University of Wisconsin Press.

Bassett, T.J. 1988. The political ecology of peasant-herder conflicts in the northern Ivory Coast. *Annals of the Association of American Geographers* 78(3): 453-472.

Bassolé, H. 2020. Zone pastorale de Sondré-Est: le Japon fait un don de 29 millions de francs CFA pour la réalisation de quatre forages. *Le Faso.net.* Ouagadougou, Burkina Faso. https://lefaso.net/spip.php?article94882 (accessed August 24, 2020).

Bauer, K. 2009. On the politics and the possibilities of participatory mapping and GIS: using spatial technologies to study common property and land-use change among pastoralists in central Tibet. *Cultural Geographies* 16(2): 229-252.

Breusers, M., 2001. Searching for livelihood security: land and mobility in Burkina Faso. *Journal of Development Studies* 37(4): 49-80.

Breusers, M., S. Nederlof and T. van Rheenen. 1998. Conflict or symbiosis? Disentangling farmer-herdsman relations: the Mossi and Fulβe of the Central Plateau, Burkina Faso. *The Journal of Modern African Studies* 36(3): 357-380.

Brottem, L. 2014. Hosts, strangers and the tenure politics of livestock corridors in Mali. *Africa* 84(4): 638-657.

Brottem, L., M.D. Turner, B. Butt and A. Singh. 2014. Biophysical variability and pastoral rights to resources: West African transhumance revisited. *Human Ecology* 42(3): 351-365.

Brown, G. and C.M. Raymond. 2014. Methods for identifying land use conflict potential using participatory mapping. *Landscape and Urban Planning* 122(2): 196-208.

de Bruijn, M.E. and H.J.W.M. van Dijk. 1999. Insecurity and pastoral development in the Sahel. *Development and Change* 30(1): 115-139.

Bryan, J. 2011. Walking the line: participatory mapping, indigenous rights, and neoliberalism. *Geoforum* 42(1): 40-50.

Cordell, D.D., J.W. Gregory and V. Piché. 1996. *Hoe and wage: a social history of a circular migration system in West Africa*. Boulder, CO: Westview Press.

Ejigu, M. 2009. Environmental scarcity, insecurity and conflict: the cases of Uganda, Rwanda, Ethiopia and Burundi. In Brauch H.G. *et al*. (eds.). *Facing global environmental change*. Berlin, Heidelberg: Springer.

Ellis, J. and K.A. Galvin. 1994. Climate patterns and land-use practices in the dry zones of Africa. *Bioscience* 44(5): 340-349.

Fernandez-Gimenez, M.E. 2002. Spatial and social boundaries and the paradox of pastoral land tenure: a case study from postsocialist Mongolia. *Human Ecology* 30(1): 49-78.

Galvin, K.A. 2009. Transitions: pastoralists living with change. *Annual Review of Anthropology* 38: 185-198.

Hagberg, S. 2001. À l'ombre du conflit violent: règlement et gestion des conflits entre agriculteurs Karaboro et agro-pasteurs Peul au Burkina Faso. *Éditions de l'École des Hautes Etudes en Sciences Sociales* 41(161): 45-72.

Institut Géographique du Burkina Faso (IGB). 2015. *Document de spécifications externes de contenu de la Base Nationale de Données Topographiques (BNDT)*, Version 1.0. Paris: IGN France International.

Institut National de la Statistique et de la Démographie (INSD). 2000. *Analyse des résultats du récensement général de la population et de l'habitation (RGPH) de 1996*. Ouagadougou, Burkina Faso.

Institut National de la Statistique et de la Démographie (INSD). 2009. *Récensement général de la population et de l'habitation (RGPH) de 2006*. Ouagadougou, Burkina Faso.

Lentz, C. 2013. *Land, mobility, and belonging in West Africa*. Bloomington, IN: Indiana University Press.

McMillan, D., J-B. Nana and K. Savadogo. 1992. Adaptation of rapid assessment procedures (RAP) to monitoring settlement trends in areas covered by successful disease control programmes: Onchocerciasis. In N. Scrimshaw and G. Gleason (eds). *RAP (Rapid Assessment Procedures): qualitative methodologies for planning and evaluation of health related programmes*. Boston, MA: International Nutrition Foundation for Developing Countries (INFDC).

McMillan, D. 1995. *Sahel visions: planned settlement and river blindness control in Burkina Faso*. Tucson, AZ: The University of Arizona Press.

Ministère des Ressources Animales du Burkina Faso (MRA-BF). 2006. *Arrêté N°2006/ 10/ PRES/PM/MRA, portant approbation du Cahier des Charges spécifique de la zone pastorale de Sondré-Est*. Ouagadougou, Burkina Faso.

Moritz, M. 2006. Changing contexts and dynamics of farmer-herder conflicts across West Africa. *Canadian Journal of African Studies/La Revue Canadienne des Etudes Africaines* 40(1): 1-40.

Moritz, M., B. Larisa Catherine, A.K. Drent, S. Kari, A. Mouhaman and P. Scholte. 2013. Rangeland governance in an open system: protecting transhumance corridors in the Far North Province of Cameroon. *Pastoralism: Research, Policy and Practice* 3(26).

Moritz, M., P. Scholte, I. Hamilton and S. Kari. 2013. Open access, open systems: pastoral management of common-pool resources in the Chad Basin. *Human Ecology* 41(3): 351-365.

Nébié, E.K. and C.T. West. 2019. Migration and land-use and land-cover change in Burkina Faso: a comparative case study. *Journal of Political Ecology* 26(1): 614-632.

Nébié, E.K. 2018. *Documenting farmer-herder livelihoods, challenges and adaptations in the Center-South Region of Burkina Faso*. Ph.D. Dissertation. Chapel Hill, North Carolina: University of North Carolina at Chapel Hill.

Nébié, E.K. 2020. Where are the women? Gendered experiences of land resource management in the time of climate change in southern Burkina Faso. In Boyd L. and E. Burrill (eds.). *Legislating gender and sexuality in Africa: human rights, society, and the state*. Madison, Wisconsin: University of Wisconsin Press.

Nébié, O. 2005. *Expérience de peuplement et stratégies de développement dans la Vallée du Nakambé, Burkina Faso.* Ph.D. Dissertation. Neuchâtel, France: Université de Neuchâtel.

N'Doh, Y. 1992. *L'Aménagement de la zone pastorale de Sondré-Est (Province du Zoundwéogo).* Mémoire de Maitrise. Ouagadougou: Université de Ouagadougou.

Niamir-Fuller, M. 1999. *Managing mobility in African rangelands: the legitimisation of transhumance*. London: Intermediate Technology.

Poole, P. 1995. Land-based communities, geomatics and biodiversity conservation. *Cultural Survival Quarterly* 18(4): 74-76.

Reenberg, A. and C. Lund. 1998. Land-use and land right dynamics—determinants for resource management options in eastern Burkina Faso. *Human Ecology* 26(4): 599-620.

République du Burkina Faso. *Loi n° 84-050/CNR/PRES du 4 Août 1984 portant Réorganisation Agraire et Foncière (RAF) et son décret d'application.* Ouagadougou, Burkina Faso.

Revelyn. 2020. Accès à l'eau potable: le Japon offre 4 forages à Sondré-Est. *Burkina24.* https://www.burkina24.com/2020/02/13/acces-a-leau-potable-le-japon-offre-4-forages-a-sondre-est (accessed August 24, 2020)

Robert, E. 2010. Les zones pastorales comme solution aux conflits agriculteurs/pasteurs au Burkina Faso: l'exemple de la zone pastorale de la Doubégué. *Les Cahiers d'Outre-Mer. Revue de Géographie de Bordeaux* 63(249): 47-71. https://doi.org/10.4000/com.5861

Somé, B. and A. Camara. 2016. *Sondré-Est: governance assessment*. LGACC Project Report No. 4. Nairobi, Kenya: ILRI.

Tappan, G., W. Cushing, S. Cotillon, M. Mathis, J. Hutchinson and K. Dalsted. 2016. West Africa Land-use Land Cover Time Series: U.S. Geological Survey data release. URL: http://dx.doi.org/10.5066/F73N21JF (accessed April 12, 2018).

Turner, M.D. 2003. Methodological reflections on the use of remote sensing and geographic information science in human ecological research. *Human Ecology* 31(2): 255-279.

Turner, M.D. 2011. The new pastoral development paradigm: engaging the realities of property institutions and livestock mobility in dryland Africa. *Society and Natural Resources* 24(5): 469-484.

Turner, M.D., A.A. Ayantunde, P.K. Patterson and E.D. Patterson III. 2011. Livelihood transitions and the changing nature of farmer–herder conflict in Sahelian West Africa. *The Journal of Development Studies* 47(2): 183-206.

Turner, M.D., J. McPeak, K. Gillin, E. Kitchell and N. Kimambo. 2016. Reconciling flexibility and tenure security for pastoral resources: the geography of transhumance networks in eastern Senegal. *Human Ecology* 44(2): 199-215.

Turner, M.D. and O. Moumouni. 2019. Mosaics of property: control of village land in West Africa. *The Journal of Peasant Studies* 46(6): 1167-1191.

Weiner, D. and T. Harris. 2003. Community-integrated GIS for land reform in South Africa. *URISA Journal* 15(2): 61-73.

West, C.T., A. Moody, E.K. Nébié and O. Sanon. 2017. Ground-truthing Sahelian greening: ethnographic and spatial evidence from Burkina Faso. *Human Ecology* 45(1): 89-101.