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Towards effective community-based cattle breeding in Burkina Faso: understanding production systems and farmers´ values, beliefs and attitudes

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Dedication

To Almighty God and

to all my family for your eternal support.

May this work be the accomplishment of your wishes and the fruit of your support!

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Abstract (English)

Community-based breeding programs (CBBPs) have been reported as a successful strategy to conserve and improve local breeds in low input systems. An essential element for successfully implementing and sustaining these breeding programs is to consider the social factors. This study was carried out in southwestern Burkina Faso, where CBBPs for local Lobi cattle and their crosses with Fulani cattle are implemented.

The objectives of this work are: (1) characterize the current production system at the farm level, (2) investigate the values, beliefs, and norms of farmers that shape the implementation of the breeding programs, (3) explore the attitudes of the different farmer groups towards different breeding tools. For achieving these goals, investigations were carried out in southwestern Burkina Faso. Therefore, a survey with 169 participants, several focus group discussions, and personal interviews were conducted to collect the empirical data. Principal component analysis was performed to describe the production system at the farm level and the farmers´ attitudes towards the breeding tools. In contrast, interview data were transcribed and coded following the Multi-level perspective framework. Four different production systems could be identified. Two of them are more crop production oriented, where savings from crop sales are invested in cattle, which in return serve as a backup system. The two other systems are more livestock-oriented, and crop production is seen as a diversification option. The transition of the Lobi ethnic group from sole crop producers towards a more livestock orientation can be seen. This transition is supported by the insecure background described by the different participants. Thus, their values were more oriented to secure their livelihoods. Therefore, participants wanted to see tangible results of the CBBPs before further committing them. Participants shared the idea of maintaining the local breeds and that breeders´ associations are one crucial element to reach this goal. There were different opinions about crossbreeding as it was seen as an economically interesting alternative. Therefore, pure breeding, but also crossbreeding strategies should be further supported as a response of the diverse farmers´ interests. Some farmers were skeptical about the practice of bull sharing as it also bears risks. For that reason, the establishment of a breeders´ association with clear obligations and roles are important elements to be considered. It can be concluded that breeding programs should reduce the risks for farmers involved and build trust among the different stakeholders. Therefore, future research should explore different risk mitigation strategies in the breeding programs.

Keywords: Breeding programs, production systems, values, beliefs, attitudes, Lobi cattle breed

Résumé (French)

Les programmes d'élevage à base communautaires (CBBP), sont considérés comme une stratégie efficace pour conserver et améliorer les races locales dans des systèmes à faibles intrants. Un élément essentiel pour la mise en œuvre réussie et le maintien de ces programmes de sélection est de prendre en compte les facteurs sociaux. Cette étude a été réalisée dans le sud-ouest du Burkina Faso où des CBBP pour les Taurins Lobi et leurs croisements avec des Zebu Peulh sont mis en œuvre.

Les objectifs de ce travail étaient : (1) caractériser le système de production actuel au niveau de l'exploitation ; (2) étudier les valeurs, les croyances et les normes des agriculteurs qui façonnent la mise en œuvre des programmes d'élevage ; (3) explorer les attitudes des différents groupes d'agriculteurs envers les différents outils d'élevage. Pour atteindre ces objectifs, des enquêtes ont été menées dans le sud-ouest du Burkina Faso. Ainsi, auprès de 169 participants, plusieurs entretiens de groupes et des entretiens individuels ont été menés pour recueillir les données empiriques. Une Analyse en Composante Principale (ACP) a été également réalisée pour décrire le système de production au niveau de l'exploitation et les attitudes des agriculteurs envers les outils de sélection. De même, les données des entretiens ont été transcrites et codées selon le cadre analytique (par exemple : les valeurs et les descriptions des moyens de subsistance). Quatre systèmes de production différents ont pu être identifiés. Deux d'entre eux sont plus orientés vers la production végétale où les revenus de la vente des récoltes sont investis dans le bétail, qui sert en retour de système d'appoint. Les deux autres systèmes sont davantage axés sur l'élevage ; et la production végétale est considérée comme une option de diversification. On peut observer la transition du groupe ethnique Lobi, qui est passé d'un système de production de cultures à un système plus orienté vers l'élevage. Cette transition est soutenue par le contexte d'insécurité décrit par les différents participants. Ainsi, leurs valeurs étaient davantage orientées vers la sécurisation de leurs moyens de subsistance. Par conséquent, les participants attendaient des résultats tangibles des CBBP pour plus de participation. Ces participants partagent l'idée de maintenir les races locales et estiment que les associations d'éleveurs sont un élément crucial pour atteindre cet objectif. Toutefois, leurs avis étaient partagés sur la réduction des métissages car ceux-ci étaient considérés comme une alternative économiquement intéressante. Par conséquent, les stratégies de sélection pure, mais aussi de croisement, devraient être davantage soutenues pour répondre aux divers intérêts des agriculteurs. Mais certains agriculteurs étaient sceptiques quant à la pratique du partage des taureaux, car, pour eux, cette pratique comporte également des risques. Pour cette raison, l'établissement d'une association d'éleveurs avec des obligations et des rôles clairs sont des éléments importants à considérer. Pour finir, les programmes de sélection doivent permettre de réduire les risques pour les agriculteurs impliqués et instaurer la confiance entre les différentes parties prenantes. Du reste, les recherches futures devraient explorer différentes stratégies d'atténuation des risques dans les programmes de sélection.

Kurzfassung (German)

Dörfliche Zuchtprogramme haben sich als erfolgreiche Strategie zur Erhaltung und Verbesserung lokaler Rassen in low-input Systemen erwiesen. Ein wesentliches Element für die erfolgreiche Umsetzung dieser Zuchtprogramme ist die Berücksichtigung der sozialen Faktoren.

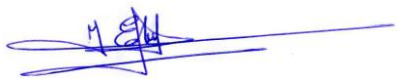
Diese Studie wurde im Südwesten von Burkina Faso durchgeführt, wo dörfliche Zuchtprogramme für lokale Lobi-Rinder und deren Kreuzungen mit Fulani-Rindern umgesetzt werden.

Die Ziele dieser Arbeit sind 1) die aktuellen Produkutionssystme auf Betriebsebene zu charakterisieren, 2) die Werte, Überzeugungen und Normen der Bauern zu untersuchen, die die Umsetzung der Zuchtprogramme beeinflussen, zu analysieren 3) die Einstellung der verschiedenen Bauerngruppen zu verschiedenen Züchtungswerkzeugen zu identifizieren. Um diese Ziele zu erreichen, wurden Untersuchungen im Südwesten von Burkina Faso durchgeführt. Dazu wurden eine Umfrage mit 169 Teilnehmern, mehrere Fokusgruppendiskussionen und persönliche Interviews durchgeführt. Eine Hauptkomponentenanalyse wurde durchgeführt, um das Produktionssystem auf Betriebsebene und die Einstellung der Bauern zu Züchtungswerkzeugen zu beschreiben. Im Gegensatz dazu wruden die Interviewdaten transkribiert und kodiert, wobei die Multi-Level-Perspektive als theoretischer Rahmen verwendet wurden. Es konnten vier verschiedene Produktionssysteme identifiziert werden. Zwei davon sind mehr auf die Pflanzenproduktion ausgerichtet, wobei die Ersparnisse aus dem Verkauf in Rinder investiert weden, die wiederum als Back-up System dienen. Die beiden anderen Systeme sind eher viehorientiert, und die Pflanzenproduktion wird als zusätzliche Diversifikationsmöglichkeit gesehen. Die Transition der ethnischen Gruppe der Lobi von reinen Ackerbauern hin zu einer verstärkten Tierhaltung ist zu erkennen. Als Begründung für diesen Veränderungsprozess wurde von den verschiedenen Teilnehmern die unsichere Produktionsslage genannt. Die Sicherung ihrer Lebensgrundlage stellt einen zentralen Punkt in der Wertevorstellung der Bauern dar. Diese Einstellung wird auch darin widergespiegelt, da sie sich greifbare Erfolge bei den Zuchtprogrammen wünschen bevor sie sich weiter engagieren. Die Teilnehmer waren sich einig, dass die lokalen Rassen erhalten werden sollten und dass die Züchtervereinigungen ein wichtiges Element sind, um dieses Ziel zu erreichen. Über die Kreuzungszucht gab es unterschiedliche Meinungen, da sie von einigen als wirtschaftlich interessante Alternative gesehen wurde. Daher sollten Reinzucht, aber auch Kreuzungszucht als Antwort auf die unterschiedlichen Interessen der Landwirte weiter unterstützt werden. Einige Bauern standen der Praxis des Stieraustauschs skeptisch gegenüber, da diese auch Risiken birgt. Daher ist die Gründung einer Züchtervereinigung mit klaren Rechten und Pflichten ein wichtiges Element, das berücksichtigt werden sollte. Daraus lässt sich schließen, dass Zuchtprogramme die Risiken für die beteiligten Bauern reduzieren und Vertrauen zwischen den verschiedenen Interessensgruppen aubauen sollten. Daher sollte die zukünftige Forschung verschiedene Strategien zur Risikominderung in den Züchtungsprogrammen untersuchen.

Declaration

I certify that I have compiled this thesis solely using sources and tools quoted in the thesis. It contains no illegitimate support. Furthermore, I declare that the thesis has not submitted anywhere else in any form.

Vienna, April 2021



Lassina Bienvenue ZOMA

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CHAPTER I

General introduction

Burkina Faso is a landlocked country located in West Africa and has a population of 18 million habitants. The Gross Domestic Product (GDP) per capita was estimated at 664 USD in 2016 (FAO, 2019). Its economy is mainly based on agriculture and the livestock sector contributed between 20 to 30 percent to the GDP in 2016. In 2019, livestock products represented 30 percent of the national exportation and livestock was the second largest agricultural sector after cotton (FAO, 2019). The livestock population is estimated at about 9 million cattle, 14 million goats and 9 million sheep and produced 35 million tons of meat and 264 000 tons of milk (FAO, 2019).

Cattle is one of the most important components of agriculture and livestock contributing 36 to 40 percent of the agricultural added value (FAO, 2019, 2018; MAHRH, 2011). That production is based on local cattle breeds which are mostly kept under extensive production systems (87 percent) (FAO, 2019). Cattle perform diverse functions in farmers' livelihoods as they have cultural and societal functions (criteria for social position, cultural identity, uses in many social, cultural and spiritual events,) (Dessie and Okeyo Mwai, 2019). In addition, they are sources of food (meat and milk), income, provide services (transport and traction) and manure for farmland and, serve as a storage of wealth and as a risk distribution strategy (Ayantunde et al., 2020; Molina-Flores et al., 2020; Nugteren and Le Côme, 2016; Nugteren and Le Côme). Cattle are the second most important source of animal protein after poultry in Burkina Faso (FAO, 2019). The demand for animal protein is expected to increase driven conjointly by the rapid population expansion and urbanization. The population is estimated to reach 45 million in 2050 and whereas the urbanization to increase from 50 to 75 % of the total population in 2050. Due to the expected changes in middleclass dietary patterns more animal sourced food will be in demand (FAO, 2019, 2018; Robinson et al., 2011). To respond to this predicted demand increase, it is important to characterize the different local cattle breeds and their production systems in a first step. Based on this assessment interventions and policies for the conservation, improvement and utilization of local breeds can be further developed to ensure a sustainable production (Vilaboa-Arroniz et al., 2008).

Therefore, in the following section a short description of the main local cattle breeds and the different production systems is provided.

I. Local cattle breeds in Burkina Faso

In Burkina Faso, cattle production is dominated by 2 local breeds (Fulani Zebu and Lobi Taurine) and their crossbreds (MRA, 2003).

The characteristics of the two cattle breeds are briefly described in the following section.

The Fulani Zebu cattle breed is the most important Zebu cattle breed encountered in Burkina Faso. Previously, it was found only in North Burkina Faso and kept by the Fulani ethnic group. However, this breed has been spread over the whole country through the transhumance movement of Fulani and reinforced by internal migration of the population from the North to the South due to the long dry seasons of the 1970s (Henry et al., 2004; Paré et al., 2008; Planchenault, 1987). (Planchenault, 1987) reported that the livestock of Northern Burkina Faso decreased by 32 % from 1969 to 1974, while the West and Southwestern parts observed an increase of 16 % in livestock numbers.

The Fulani Zebu cattle has a height at withers of 120 – 150 cm and an average weight of 250 – 400 kg (Traoré et al., 2015). This cattle breed is known to have a high market value because of their meat and milk potential. The disadvantage of this breed is its susceptibility against trypanosomiasis, causing higher veterinary costs for the owners (Grace et al., 2020).

Lobi Taurine cattle, known as Baoulé in Côte d'Ivoire, is the most common taurine cattle in Burkina Faso largely found in the South-Western region and owned by the Lobi ethnic group (Dessie and Okeyo Mwai, 2019; Mopaté et al., 2014). This breed is characterized by its small size (90 – 106 cm) and body weight (150 -200 Kg) (Traoré et al., 2015; Yougbaré et al., 2020). The Lobi has a low market price and therefore, it is less preferred compared to the Fulani cattle. Lobi cattle are known for their resistance to trypanosomiasis (Belemsaga et al., 2005; Dessie and Okeyo Mwai, 2019; Soudré et al., 2013; Yougbaré et al., 2020). These qualities, in conjunction with its adaptability to high temperature, long drought conditions low inputs and ease to handling make the Lobi an especially valuable livestock asset. Furthermore, this breed is more valued for its socio-cultural and spiritual functions than its economic ones (Dessie and Okeyo Mwai, 2019; Mopaté et al., 2014). The Lobi cattle are passed on to the inheritors via the maternal side. Their main destiny is to construct a collective wealth (De Rouville, 1987; Fiéloux, 1980; Rouville, 1984; Soro et al., 2015). According to (Dessie and Okeyo Mwai, 2019) the Lobi cattle provide bigger return on investment compared to larger breeds.

Besides the qualities of the Lobi Taurine, the low market value of this breed leads to frequent crossbreeding with Fulani Zebu. This practice is common, as Lobi animals are often herded together with Fulani Zebu as they are under the management by Fulani herders (Mopaté et al., 2014; Soro et al., 2015). This practice threatens the Lobi Taurine, which has, therefore, been classified as an endangered breed (FAO, 2010, 2015, 2007; Mopaté et al., 2014).(FAO, 2019) recommends the conservation of local breeds as they contribute to the agro-biodiversity and genetic diversity for any breeding program. (Kamuanga et al., 2001) suggest that the conservation efforts of the Lobi breed should be directed in the southern region of Burkina Faso where the breed is better suited to the farming system and targeted to households with a higher overall perceived advantage of the trypanotolerant breed over Zebu-type cattle.

II. Overview on cattle production systems in Burkina Faso

Livestock production systems (LPS) can be classified according to following criteria: the management, animal movement, the purpose of keeping the animals, ethnic group and the agro-ecological zone (Tarawali and Hiernaux, 2002). In Burkina Faso the LPS can be classified in two main groups: the traditional or extensive system (87 percent) and the modern, improved or intensive system (13 percent) (FAO, 2019; Tarawali and Hiernaux, 2002). The extensive system can be further divided into two categories: the pastoral (transhumant) and the agro-pastoral (sedentary) systems. The improved system can also be broken down into two categories: the intensive (11 percent) and the semi-intensive (2 percent) system.

2.1. Extensive system

The extensive system is found throughout the country with a strong predominance in the Sahel and the eastern region. Cattle are often reared with sheep and goats. The core feature of this system is that animals are reared on communal pasture and use water sources such as rivers and wells. Post-harvest fodder is also used in this system. Some agro-industrial by-products are provided to calves, weak animals and cows in milk. Animal health protection is mostly based on obligatory governmental vaccination programs for some declared diseases. In this system, farmers keep large herds for social prestige but are not necessarily market oriented. Nevertheless, this system has about 87% of the national cattle population, provides around 90% and 95% of the national beef and milk respectively and 95% of the exported cattle are from this system (FAO, 2019).

The major constraints of this system are the scarcity of water and pastures, especially in the dry season, animal diseases and lack of veterinary facilities, loss of cattle through theft and conflicts between farmers (De Haan et al., 2016; Minot and Elahi, 2020).

Below, a brief description of the two categories of the extensive system is provided.

The pastoral system is a category in which farmers move with their cattle seeking pasture and water. Pastures are not fenced, but sometimes trees are used as temporary fences. Nearly all the farmers of this system are from Fulani ethnic group and rear Zebu cattle and some crossbreds (De Haan et al., 2016; Minot and Elahi, 2020). The pastoral system can be split into the large transhumance system in which farmers move for hundreds of kilometers and even sometimes beyond the borders of the country (De Haan et al., 2016; Minot and Elahi, 2020). The second group is the semi-transhumant system where farmers move to neighboring regions and settle for a short time mostly during the rainy season.
In the pastoral system, most of the milk is for home consumption. Women sell the surplus of milk to cover the expenses of the family´s daily needs.

The agro-pastoral system is characterized mostly by its integration with crop production. Farmers from this system are mostly crop producers who saved the income from crop

production by buying some animals and some herders who lost their animals then settled and adopted crop production as an activity to reconstruct their herd (Rigolot et al., 2017). This system includes all types of cattle breeds. Farmers with large numbers of cattle rely on paid workers for herding the animals because of lack of knowledge and also to have more laborers for the crop activities. Some farmers, who have small numbers of cattle, rely on family labor mostly children who are considered less useful for crop activities. In this system, herders move daily with cattle within a short distance during the rainy season. After the harvest, cattle are left either for free grazing (mostly in the South-western region) or are kept on the crop fields (Mopaté et al., 2014). In this system, farmers have some fences built with local material or woods to permit the accumulation and easy collection of the manure for the crop field.

2.2. Intensive system

The intensive system is mostly found in the peri-urban areas and represents 13 percent of the national cattle population. This system is fully market oriented, and the social role of cattle is taken over by the economic purpose with profit seeking (Dossa et al., 2015; Roessler, 2019; Tarawali and Hiernaux, 2002). Therefore, farmers invest a lot in the inputs such as feeding, health care, infrastructures and specialized paid labor such as veterinary services. Here, some exotic breeds such as Brunes des Alpes, Holstein Friesian, Montbéliarde, Brown Swiss, Tarentaise, Gir, Girlando, Jersey and Normande are used (FAO, 2018; Roessler, 2019). In addition, local breeds from neighboring countries such as the Zebu Azawak and Gudali are also used. In this system, natural mating remained the main mating system combined with the use of Artificial Insemination (AI) (Roessler, 2019).The main constraint of this system, in addition to the adaptability of the exotic breeds, is the high cost of the production inputs.

The two categories of the intensive system are the intensive and the semi-intensive systems. The main difference between these two components is the degree of inputs used by farmers. The intensive system shares similarities with the “landless system“ described by (Robinson et al., 2011; Thornton, 2002).

In summary, the cattle production is mainly based on the extensive system with low inputs based on local breeds and their crosses. The frequent crossbreeding could threaten the pure local breed, particularly the Lobi breed. Thus, there is a necessity to develop strategies for sustainable utilization to conserve this breed. The improvement of the Lobi breed is one of the keys to its conservation since this is the main reason of its owners for crossbreeding. In this context of a low input system, Community-based breeding program (CBBP) could be a viable solution for the conservation of the Lobi breed.

III. Community-based based breeding programs

Mueller et al. (2015) defined community-based breeding programs as typically related to low input livestock production systems in developing countries with farmers within limited geographical boundaries having a common interest to improve and share their genetic resources.

The main characteristics of the CBBPs have been elaborated by Mueller et al. (2015):

- The geographical is limited to some communities;
- The production mainly for subsistence and surplus to be sold on market;
- The main agent of the program is the farmer (breeder);
- The breeding objective is defined by the breeder;
- The breeding structure is on small scale;
- The genetic resource is typically local;
- The infrastructure is limited;
- The management is low input and mostly extensive system;
- The risk taker and the main decider to share the benefits is the farmer.

CBBPs are seen as a viable solution for farmers in developing countries to share and improve the genetic resources of local breeds. Therefore, CBBPs have been widely implemented to improve local breeds. Implementations of the CBBPs were reported for different species and countries: for sheep in in Ethiopia (Duguma et al., 2011; Haile et al., 2011; Mirkena et al., 2012), goats in Mexico and in Kenya (Ojango et al., 2010; Wurzinger et al., 2013), in pig in Vietnam (Markemann and Valle Zárate, 2009; Roessler et al., 2012). In Burkina Faso, an on-going cattle CBBP has been reported by Ouédraogo et al. (2019).

Some success stories of these breeding programs, mainly in small ruminants, were reported in Ethiopia (Haile et al., 2019). The successes of these programs were attributed to their compatibility with the breeding objective of the farmers and the full participation of these farmers, the existence of strong professional structures (breeders´ association) and active technical extension services (Haile et al., 2020).

Besides these successes, the failures of breeding programs were reported in many cases (Kosgey et al., 2006; Mueller et al., 2015; Rewe et al., 2009). In the most cases, the lack of organization of the breeders, the lack of public financial support, the insufficient involvement of farmers, the different interests of the farmers, the incompatibility of some programs with the farming system that sometimes farmers found the programs unsuitable, unprofitable, too risky, too labor intensive or impossible to implement which resulted in the non-participation of the farmers. In addition, farmers' knowledge and perceptions were often not considered (Kosgey et al., 2006; Martin-Collado et al., 2018; Mueller et al., 2015; Rewe et al., 2009; Wurzinger and Gutierrez, 2017).

Therefore, the implementation of a breeding program should consider the full participation of the farmers from the inception and design to the implementation and the evaluation (Mueller et al., 2015; Sölkner et al., 1998). Thus, the description of the current production system, the design of the breeding objectives has to go along with the needs of the farmers (Mueller et al., 2015; Sölkner et al., 1998; Wurzinger and Gutierrez, 2017). Moreover, the values, the beliefs and the attitudes of the farmers towards the breeding tools need to be considered (FAO, 2010; Martin-Collado et al., 2020).

IV. Theoretical considerations

4.1. Agricultural systems

Changing agricultural practices to increase productivity, income, and food security has been the objective of research and policy for many decades. While linear and essentialist approaches - aiming to maximise the transfer technologies from research to farm - prevail, systemic approaches taking a holistic perspective have become increasingly mainstream (Norman, 2002; Darnhofer et al., 2012).

Von Bertalanffy (1956) defined a *system* as an entity, which maintains its existence through the mutual interaction of its parts. The concept of system thinking allows a more comprehensive picture of realities taking into account multiple perspectives (Chapman, 2004). Systems thinking, when operationalised, can provide the concepts and tools to understand complex developments in agriculture and society better. The application of agricultural systems thinking to livestock production was illustrated by (Darnhofer et al., 2012), who compared livestock and livestock-farming systems. While livestock scientists would focus their studies on individual animals (feeding, genetic, breeding), research into livestock farming systems studies, for example, the interactions between farmer and animals, the constraints in farm management or the definition of "efficiency" or "success" by the farmer. Gibon et al. (1999) highlighted that livestock-farming system research focuses on the farm rather than animal or herd as the primary level of analysis. It recognises the need for a participatory approach, acknowledging the agency of the farmer in shaping the farming system.

In this thesis, I relied on agricultural systems thinking as an overall theoretical perspective.

4.2. Change and innovation in agricultural systems

Agriculture remains the primary source of livelihood for most smallholders who live in rural areas (McIntyre et al., 2009). The increase in population, including in rural areas, as well as adverse effects of climate change on agricultural production, have raised concern regarding the need for accelerated agricultural innovation to tackle global food security challenges and reduce rural poverty (Brooks and Loevinsohn, 2011; De Janvry and Sadoulet, 2002). Previous studies have suggested a positive impact of adopting novel technologies on productivity, income, food security, and poverty reduction (Asfaw et al., 2012; Kassie et al., 2011). The question of how technologies can best be transferred to the farm level has been researched for many years (Gatzweiler and Von Braun, 2016).

Going beyond adoption, *innovation* has been defined as including both a technological factor and a corresponding change in organization and knowledge in a given situation (Feder and Umali, 1993; Snapp and Pound, 2017). Over time, the concept of innovation itself has evolved: early concepts proposed that novel technology or approaches diffuse over time, assuming informed rational choices by agricultural producers (Rogers, 1962). Brown (1981) argued that decisions to adopt novel approaches are associated with the social, economic, and psychological characteristics of the potential adopters. From this perspective, innovation was understood as the "transfer of technology" involving public sector research and extension organizations

(Islam, 2014). The farmers´ role was to learn, adopt and conform to the technology proposed by scientists (Jarrett, 1985).

Chambers and others have criticized this paradigm, highlighting the agency of farmers and their role as ultimate decision-makers, and thus proposing to put "farmers first" (Chambers et al., 1989; Chambers and Ghildyal, 1985). Change and innovation, from this perspective, is a process of co-creation based on the farmer´s perceptions and priorities.

The idea that changes in agricultural practices emerges from a system has been formalized in Agricultural (Knowledge and) Innovation Systems (AKIS) and Farming System Research (FSR) (Norman, 2002). AIS approaches, considering actors, their interactions, and institutions are currently mainstream in the field of development research and practice (Klerkx et al. 2012). Multi-stakeholder processes, often operationalized as platforms, are typical examples of AIS approaches (Schut et al. 2016). The essentialist concept of *adoption*, however, remains common and investigates mainly static characteristics of the farmer as a rational agent and institutional settings. This thesis emphasizes the role of social factors such as values and beliefs, which could influence the farmers' choices so that their understanding is very relevant to support CBBPs.

4.3. Values, beliefs and attitudes driving change and innovation

In line with the mentioned concepts of "farmer first" and AIS, I considered the farmer the central actor in the farming system. Her or his values and beliefs are crucial to the understanding of how the agricultural system can evolve (Soni et al., 2014). In these terms, I hypothesized that the breeding program needs to align with the values, beliefs of the farmers. Schwartz (Schwartz, 1992) defined values as a "*belief pertaining to desirable end states or modes of conduct, that transcends specific situations, guides selection or evaluation of behavior, people, and events and is ordered by importance relative to other values to form a system of value priorities"*. Based on that, Schwartz developed a framework of basic human values (Schwartz, 1992). The ten basic values are positioned along two bipolar dimensions: *openness to change* versus *conservation* and *self-enhancement* versus *self-transcendence*. Stern (1999; 2000) expanded on this framework by suggesting a value-belief-norm theory that constitutes a causal chain in which values can affect beliefs, which will activate some personal norms and turn to actions. VBN has been used to explore farmer´s intention in relation to practices related to natural resource management (Seymour et al., 2010).

Attitudes, *"a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour"* Eagly and Chaiken (1993), have been conceptualized as more closely related to specific actions than transcending values. Understanding attitudes can be seen as complementary to a more open investigation of values. Martin-Collado et al. (2020) highlighted the importance of farmers´ attitudes towards breeding tools as regards their participation in a breeding program.

Values, beliefs and attitudes from a systemic perspective were the main theoretical frameworks of this thesis, as elaborated on in more detail in the different papers.

V. Project LoCaBreed

This thesis was carried out within the project "Local Cattle Breeds of Burkina Faso – Characterization and Sustainable Utilization (LoCa-Breed)".

The project "LoCaBreed "was established with the main objective to contribute to farmers´ livelihood improvement, to better characterize Burkina Faso´s local cattle breeds and to develop breeding strategies.

Specifically, the project aims were:

i) To strengthen research capabilities of Burkina Faso in animal breeding and genetics for sustainable management of farm animal genetic resources (FanGR);
ii) To characterize local cattle breeds at phenotypic and genetic levels for improvement taking into account indigenous knowledge;
iii) To initiate sustainable breeding and conservation programs for Lobi and Zebu x Lobi crosses using community based breeding approach.

The project was jointly implemented by researchers from different universities (Université Nazi Boni and Université Norbert Zongo), research institute (Institut de l´Environnement et de Recherches Agricoles) in Burkina Faso, the International Livestock Research Institute (ILRI) and two Austrian universities (University of Natural Resources and Life Sciences, Vienna and University of Veterinary Medicine Vienna). The project was funded by the Austrian Development Agency through the Austrian Partnership Programme in Higher Education and Research for Development (APPEAR project 120).

The project adopted the community-based breeding programs approach to ensure a better acceptance of the local stakeholders and the sustainability of it results. Community-based breeding program is a suitable approach for low input systems and has been successfully implemented for small ruminants in different countries. The program was jointly designed and implemented by farmers and scientists. The study region was in the south-western part of Burkina Faso as this region is known for its important population of the Lobi taurine cattle breed.

VI. Aims of the thesis

The aim of this study is to analyze how and to which extent social factors, but also attitudes, norms and beliefs of different farmer groups influence the implementation of community-based breeding programs for Lobi Taurine and Fulani Zebu X Lobi Taurine crosses cattle in Southwestern Burkina Faso.

The specific objectives of this thesis are:

- Characterize the current production system at the farm level;
- Investigate the values, beliefs and norms of farmers that influence the implementation of the breeding programs;
- Explore the attitudes of the different farmer groups towards different breeding tools.

VII. Outline of the thesis

The present thesis is structured in five chapters. The first and the last chapter present the general introduction and discussion. Chapter two, three and four are manuscripts that have been submitted to journals.

The **first chapter** presents a general introduction of the thesis and provides an overview on different concepts used. At the end of the chapter the general and specific objectives of the thesis are outlined

The **second chapter** describes the different production systems in the southwestern region Burkina Faso, our study area. We conducted a survey with 169 farmers. Based on the survey dataset the different production systems were constructed using factor analysis of mixed data and hierarchical clustering. The identified production systems were compared using statistical test to determine any significant difference.

The **third chapter** investigates the social norms and beliefs of the farmers that could shape the breeding programs. We purposefully sampled 34 farmers from the different production system described in the first chapter. To the aim of the chapter, the theoretical framework of Schwarz (Schwarz, 1992) on values, beliefs and norms and the analytical framework of rural livelihood transitions (El Bilali et al., 2017) were used to code the transcribed interview. Following the research questions, the difference codes were analyzed using occurrence and co-occurrence frequency.

The **fourth chapter** explores the attitudes of the farmers towards the breeding tools to understand what can lead to their uptake by the farmers and the sustainability of the CBBPs. We surveyed 125 farmers and used a questionnaire applying a six-level Likert scale.

The last **chapter** summarizes the main messages and implications of the thesis. It concludes that farmers willing to keep the features of the different local cattle breeds so improving these breeds and conserving them for sustainable utilization though the CBBP could be a viable solution. At the same time, we suggest that the breeding program needs to be run considering the specificity of each community.

CHAPTER II

From farmers to livestock keepers: a typology of cattle production systems in south-western Burkina Faso

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Abstract

Cattle production is an essential livelihood strategy in south-western Burkina Faso. Although having a distinct cultural role and known to be resistant against African animal trypanosomosis, the Lobi taurine cattle breed is endangered due to its low market value. As the first step in preservation efforts, our study aimed to develop a typology of production systems at the farm-level. We used a structured questionnaire and focus group discussions for collecting data on household characteristics, socio-economic activities, livestock, and access to services. The sample comprised 169 households in three communities. The analytical strategy included Factor Analysis of Mixed Data and Hierarchical Clustering. We identified four distinct types of cattle production systems: 1) Sedentary Lobi farms, 2) Sedentary crossbreed farms, 3) Semi-transhumant Fulani zebu farms, and 4) Transhumant Fulani zebu farms. Significant factors in developing this typology were the farmers' ethnic group, crop diversity, cattle herd size, cattle herd composition, number of small ruminants, and livestock management strategies. Across all production systems, men were considered being primary decision-makers in cattle production, with women, herders, and children being responsible for specific tasks. All identified production systems are increasingly confronting disease pressure and scarcity of water and land. Future efforts in preservation and breeding will need to respond to these trends in the agroecosystem, integrate risk management measures, and resonate with the specific needs of the different household members involved in cattle rearing.

Key words: farming system, indigenous cattle, Burkina Faso, Lobi taurine cattle, zebu cattle, crossbreds

I. Introduction

In Burkina Faso, the cattle production sector contributes between 36% and 40 % to total agricultural added value and 26% to agricultural export value (FAO 2018; MAHRH, 2011). Two species of cattle, *Bos taurus* and *Bos indicus*, are kept by farmers, agro-pastoralists and pastoralists. Cattle are a valuable source of food (meat and milk products), provide services (transport and traction), function as a savings and insurance, and play a central role in the culture of different ethnic groups (Jahnke, 1982; De la Rocque et al., 2001). The production strategies are based on local cattle breeds and have been described as extensive systems, including mixed crop-livestock, agro-pastoral, and pastoral systems (Kaboré, 2012). Members of the Lobi ethnic group, practicing sedentary mixed crop-livestock farming, have traditionally kept Lobi taurine cattle (Coulibaly, 1989; Sicot, 1992, Mopaté et al., 2014). Lobi taurine cattle are known to be resistant against African animal trypanosomosis (Sow, 2005; Dayo, 2009, Soudré et al., 2013). However, this breed is unpopular, mainly due to its small size and low market value. Consequently, livestock keepers frequently crossbreed Lobi taurines with larger Fulani zebu. This practice threatens the Lobi as a breed, which has, therefore, been classified as endangered

(Sokouri et al., 2009). The Fulani zebu breed originates from the semi-arid north of Burkina Faso and is traditionally reared by Fulani pastoralists, who move with their herds to the southern region of the country in search for pasture land and water. Previous studies described the cattle production systems in the region concerning the socio-economic use of cattle (Coulibaly, 1989), different technical management parameters (Sicot, 1992), and the degree of integration with crop production (Tano et al., 2001). Mopaté et al. (2014) evaluated the castration of bulls of other breeds as a practice to ensure the conservation of the Lobi breed.

Given the farmers' preference for breeds with high market value, the productivity of Lobi taurine needs to be improved if the breed is to be preserved. Although Lobi cattle have low productivity in terms of meat and milk, they fulfill a fundamental role in Lobi society and are used in specific cultural events. Therefore, proper management of the breed is relevant to maintain it as an integral part of cultural identity (FAO 2015).

To achieve this, community-based breeding programs (CBBPs), an approach to involve livestock keepers in systematic breeding and management efforts, could be a viable option. CBBPs have been successfully implemented to improve mainly small ruminant production—e.g. of Djallonké sheep in Cote d´Ivoire (Yapi-Gnoaré, 2000), Deccani sheep in India (Nimbkar et al. 2002), dairy goats in Mexico (Wurzinger et al. 2013), sheep in Ethiopia (Duguma et al. 2011; Haile et al. 2011; Mirkena et al. 2012), and goats in Iran and Kenya (Mueller, 2013; Ojango et al. 2010).

For implementing CBBPs, a thorough understanding of current production systems and farmers' needs is essential (Sölkner et al., 1998; Kruska et al. 2003; Dossa et al. 2009; Scherf & Tixier-Boichard, 2009; FAO 2010; Wurzinger et al., 2011; Robinson et al. 2014). As a first step in preservation efforts, our study aimed, therefore, to develop a typology of production systems at the farm-level in south-western Burkina Faso.

II. Materials and methods

2.1. Study area and sites

The study was carried out in the south-western region of Burkina Faso, located at a latitude of 10°19`00`N and a longitude of 3°10`00`W, covering about 16,533 sq.km (MEF/DREP, 2014). The region lies in the mountainous South Sudanese phytogeographical zone, with a rainy season from April to October and a dry season from November to March. The annual precipitation totals between 900 and 1200mm, with temperatures ranging from 21°C to 32°C (ANAM, 2017). Forest and savanna dominate the vegetation (MAHRH and GTZ, 2014). About 850 000 people live in the region, and the population growth rate is about 4.5 percent, including a positive net migration rate of 2 percent (INSD, 2018). The population is composed of different ethnic groups, which are considered being local (Lobi, Dagara, Birifo, Djan and Pogouli) or immigrants from other regions of Burkina Faso (Mossi, Fulani, and Bobo).

For the research, we focused on the administrative units of Bouroum-Bouroum, Kampti, and Loropeni in the Poni province. The province is typical for the region in terms of pastoral and agricultural system dynamics, as it attracts an influx of migrants from areas with less rainfall

and higher chances of drought. In the province, all three types of cattle which are common in Burkina Faso are kept: zebu, taurine, and crossbreds between them.

2.2. Data collection

We collected data using a structured questionnaire and focus group discussions (FGD) from May to September 2018. The sampling population included farmers and pastoralists of three municipalities. For lack of a registry of agricultural producers in the area, we could not apply probability sampling and resorted to a purposive sampling strategy. We collaborated with local extension workers and farmer-leaders to identify households that represent the diversity of production systems in the region, and 169 heads of household (all male) agreed to participate. We tested the questionnaire with 15 farmers as a means to improve the final design of the research instrument. We tested the questionnaire with 15 farmers as a means to improve the final design of the research instrument.

The questionnaire comprised household characteristics, socio-economic activities, livestock data, and access to services such as input supply, credit and veterinary services. Farmers were asked to score production and management constraints by applying a scale of 1 to 4 (1=not important/least serious and 4=very important/most serious).

In a second step, we held separate focus group discussions with Lobi and Fulani respondents to triangulate and illustrate the survey results with qualitative data. 20 Fulani men and 17 Fulani women attended the first focus group discussion, and 35 Lobi men and 25 Lobi women attended the second focus group discussion. To reduce possible gender effects on the discussion dynamics, men and women were invited to work on the same questions in separate groups. For validation and further discussion, each group then shared the results in a plenary setting. With the participants' consent, we audio-recorded the discussions and documented visual exercises with a digital camera.

All activities were carried out in the local languages preferred by respondents (Dioula, Moore, and Lobiri).

2.3. Data analysis

The qualitative data collected in the FGDs were compiled as written notes for triangulation and interpretation of the survey data.

The survey data were entered into Excel and analyzed using R (v 3.6.1). To explore the data, we used descriptive statistical parameters (mean, standard deviation, minimum and maximum).

To develop a typology of production systems, we applied Hierarchical Clustering on Principal Components (HCPC). We reduced the dataset dimensions into non-correlated dimensions, explaining much of the variance of the original dataset, using Factor Analysis of Mixed Data (FAMD). FAMD allows conducting a principal component analysis on datasets containing both categorical and continuous variables. Subsequently, we performed a Hierarchical Cluster Analysis (HCA). As input to the FAMD, we used sixteen variables (4 categorical and 12 continuous) (Table 1). We interpreted the Scree plot (Fig. 1) to determine the appropriate number of dimensions to be retained for clustering (Joliffe, 1986). The hierarchical clustering

was performed using Ward's method, and the gap statistic (Tibshirani et al., 2001) was employed to infer the most appropriate number of clusters. This is done by bootstrap iterations until convergence is reached. The analysis and visualization were performed using the *FactoMinerR* and *factoextra* packages in R. The identified clusters were compared using χ^2 tests for categorical variables and the non-parametric Kruskal-Wallis test followed by Wilcoxon-tests with Bonferroni-Holm correction for pairwise comparison of continuous variables. Statistical differences were considered significant at $p<0.05$. The production constraints were ranked using rank means.

III. Results

3.1. Typology of production systems

The characteristics of the sample are summarized in Table 1.

Table 1: Sample characteristics

Categorical variables	***Category***			***n***	***%***
Ethnic group	Fulani			58	34.32
	Lobi			111	65.68
Hiring labour	Yes			91	53.85
	No			78	46.15
Cattle purchase	during the past 12 months			50	29.59
	not during the past 12 months			119	70.41
Cattle feed supplement	used during dry season			165	97.63
	not used			4	2.37
Continuous variables	***Description***	***Mean***	***SD***	***Min***	***Max***
Total farmland area	Farm size (ha)	4.7	3.84	0	20
Total cashew area	Cashew farm size (ha)	2.2	4.45	0	30
Crop diversity	Number of vegetable varieties grown	3.3	1.50	0	8
Cattle (excl. oxen)	Number of cattle (excl. oxen) in the herd	53.01	67.47	0	400
Oxen	Number of oxen in the herd	2.47	2.01	0	10
Zebu	Number of zebu in the herd (head of cattle)	32.19	63.67	0	404
Crossbred	Number of crossbred in the herd	14.69	31.74	0	202
Taurine	Number of taurine in the herd	8.6	10.96	0	64
Sheep	Number of sheep	14.91	17.61	0	110
Goat	Number of goats	12.28	11.66	0	50
Vaccinations per year	Number of vaccinations per year	2.39	1.36	0	5
Cattle sold	Number of cattle sold during past 12 months	4.87	7.46	0	47

We included sixteen variables (Table 1) in the FAMD and retained four principal components based on the Scree plot (Figure 1): the Scree curve is steep, and the "elbow" is located at four dimensions (cut-off point). These four dimensions describe 62.15% of the total variance (Table 2).

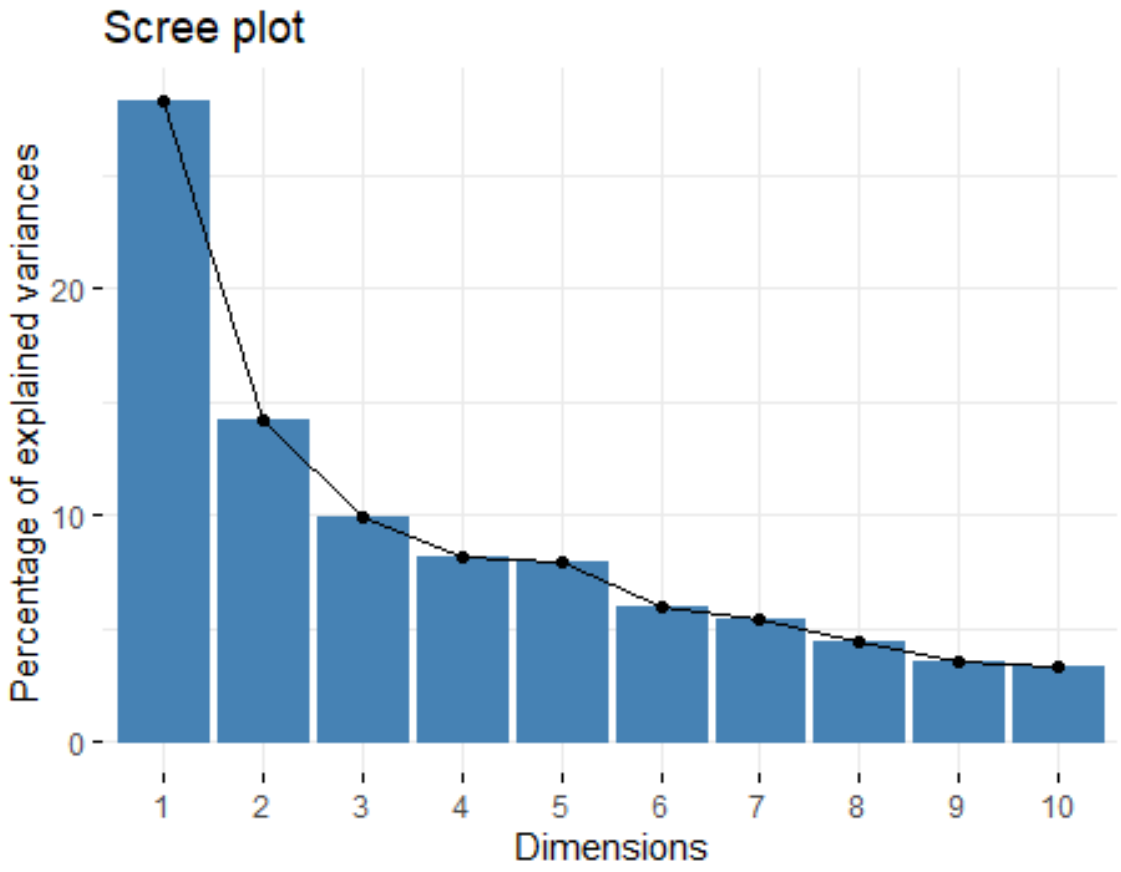

Fig. 1 Scree plot illustrating the percentage of variation explained by dimension

Table 2: Results of FAMD: factor loadings

Name of Variables	Components			
	1	2	3	4
Hiring labour	**-0.664**	-0.188	0.196	0.361
Ethnic group	**0.877**	-0.192	0.212	-0.152
Cattle purchase	0.436	-0.347	0.036	0.031
Cattle feed supplement	-0.143	-0.330	-0.042	0.491
Total farmland area	**-0.566**	**0.562**	-0.011	0.044
Total cashew area	-0.287	0.369	-0.467	-0.107
Crop diversity	**-0.745**	0.306	-0.199	0.144
Cattle (excl. oxen)	**0.757**	0.411	-0.100	0.422
Oxen	-0.210	**0.711**	0.073	-0.033

Zebu	**0.775**	0.211	-0.038	0.462
Crossbred	0.236	0.446	-0.232	-0.133
Taurine	**-0.569**	0.145	0.293	0.291
Sheep	0.162	0.224	**0.734**	-0.153
Goat	-0.048	0.379	**0.694**	-0.044
Vaccinations per year	**0.628**	0.322	-0.150	-0.379
Cattle sold	**0.751**	0.308	-0.020	0.406
Eigenvalues	4.96	2.18	1.54	1.26
Variance (%)	31.03	13.62	9.64	7.86
Cumulative variance (%)	31.03	44.65	54.29	62.15

N.B. Bold numbers refer to loadings higher than 0.5

The cluster analysis yielded four distinct clusters, which we subsequently compared to develop the typology of production systems. For each cluster, we chose a name that represents its most characteristic features (Table 3).

Table 3. Characteristics of different production system in south-western Burkina Faso

	Cluster			
	1	2	3	4
	Sedentary Lobi taurine n=68	Sedentary crossbreed n=42	Semi-transhumant Fulani zebu n=45	Transhumant Fulani zebu n=14
Ethnic group				
Fulani (persons)	0	0	44	14
Lobi (persons)	68	42	1	0
Household attributes				
Household size (persons: mean/SD)	14.8^{a}/8.34	16.2^{a}/7.82	10.8^{b}/4.98	16^{a}/6.09
Age of household head (years: mean/SD)	55.4^{a}/11.33	51.4^{ab}/11.43	46.2^{b}/13.55	49.9^{ab}/8.43
Education of household head				
Literate (%)	10.29	35.71	11.11	7.14
Illiterate (%)	89.71	64.29	88.89	92.86
Main purpose of cattle production				
Cattle for saving/insurance (%)	10.30	47.62	0.89	14.29
Cattle as draught animal (%)	58.82	38.09	00	00
Cattle for sacrifices, dowry and others social events (%)	30.88	14.29	00	00

Cattle as main source of livelihood (%)	0	0	91.11	85.71
Livestock ownership and management				
Cattle excl. oxen (number of animals: mean/SD)	18.1^{a}/12.96	49.2^{b}/55.10	58.8^{c}/36.89	215.4^{d}/93.94
Oxen (number of animals: mean/SD)	2.6^{a}/2.13	3.2^{a}/2.41	1.5^{b}/1.12	2.3^{ab}/1.07
Total cattle (number of animals: mean/SD)	20.7^{a}/13.54	52.4^{b}/55.51	60.3^{b}/37.24	217.7^{c}/94.23
Taurine (number of animals : mean/SD)	17.3^{a}/11.90	5.3^{b}/4.79	0.9^{c}/3.27	0.9^{c}/2.67
Crossbred (number of animals: mean/SD)	1.1^{a}/2.51	33.6^{b}/48.79	14.1^{c}/21.15	26.1^{bc}/41.18
Zebu (number of animals : mean/SD)	2.3^{a}/4.03	13.6^{b}/25.49	45.3^{c}/40.49	190.7^{d}/106.15
Hired labour (%)				
Yes	8.82^{a}	73.81^{b}	91.11^{c}	92.86^{bc}
No	91.18	26.19	8.89	7.14
Cattle bought (%)				
Yes	39.71^{a}	50^{a}	4.44^{b}	00^{b}
No	60.29	50	95.56	100
Cattle sold (number of animals : mean/SD)	1.3^{a}/1.4	3.1^{b}/4.26	6.1^{c}/4.91	23.5^{d}/10.75
Small ruminants				
Sheep (number of animals: mean/SD)	14.6^{a}/15.65	6.9^{b}/9.21	23.2^{a}/23.67	13.6^{ab}/11.63
Goat (number of animals: mean/SD)	14.3^{a}/11.94	8.7^{b}/9.52	12.9^{ab}/11.88	10.9^{ab}/13.83
Agriculture				
Crop farm size (hectares: mean/SD)	6.3^{a}/3.82	6.4^{a}/3.84	1.6^{b}/1.25	2^{b}/1.21
Cashew cropping area (hectares: mean/SD)	1.6^{a}/2.13	6.3^{b}/6.99	0.02^{c}/0.15	0.07^{c}/0.27

^{abc} Means within rows that do not have a common superscript are significantly different at $p<0.05$ level

The first type of production system—which we refer to as "Sedentary Lobi taurine farms"—comprised 40.24% of the interviewees, all of whom were Lobi. This system was characterized by a low number of cattle (an average of 20.7 heads) with the vast majority being taurine cattle (83.57%) for draught, saving and insurance, and social functions such as funerals, sacrifices, and dowry (Table 3). In this system, the cattle were herded by children in the rainy season, and free grazing was practiced after the crop harvest and during the dry season. The frequency of treatment against trypanosomosis was low due to natural resistance in taurine cattle. Farmers rarely sold their cattle, and when they did, it was only in case of urgent financial needs.

The second system—which we refer to as "Sedentary crossbreed farms"—was also focused on crop production, but cattle played a more central role as a mechanism for savings and insurance, as draught animals, and as providers of manure for crop production. Farmers pursuing this strategy raised at least two types of cattle, with the majority being crossbred (64.12%), mainly used as draught animals, according to farmers (FGD). Crossbred animals were also considered

more resistant to trypanosomosis than zebu and more profitable than taurine. The average number of cattle per household was about 52 heads (Table 3). The farmers relied on paid workers for herding the animals throughout the year. Similar to the "Sedentary Lobi taurine farms" strategy, cattle were not sold regularly.

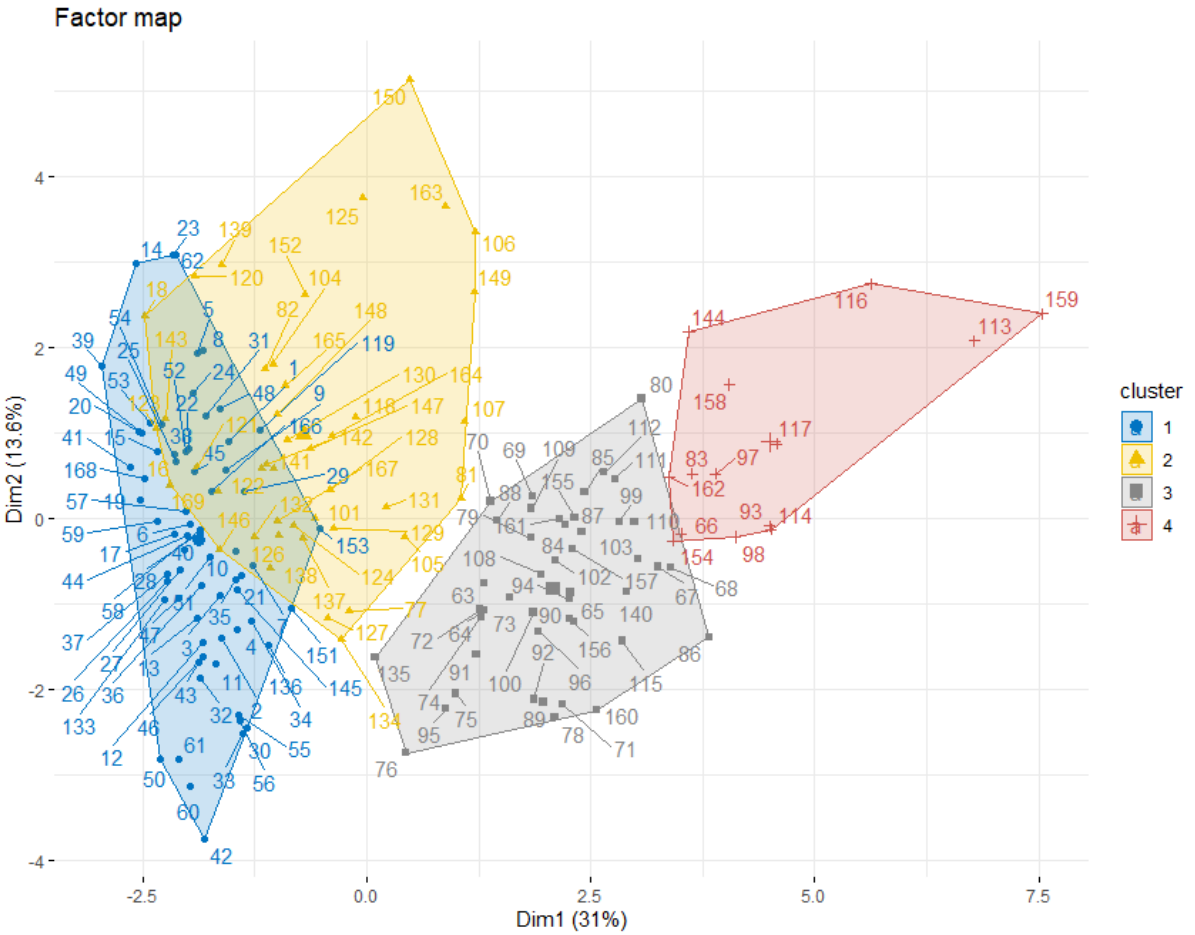

Fig. 2 Cluster plot showing the four clusters (outcome of the hierarchical cluster analysis) in the FAMD component 1 and 2 plane

In the third production system — which we refer to as "Semi-transhumant Fulani zebu farms"— interviewees focused on milk and meat production for the market, with limited crop production of sorghum or millet for home consumption. Contrary to the two first production systems, the vast majority of producers were Fulani (97.78%). Considering the crucial role of livestock for their livelihoods and also the higher number of zebu in this production system (75.12%), the respondents indicated higher costs for fencing, feed, and veterinary services. Furthermore, this system, with an average of about six cattle sold a year, was more cattle market-oriented than clusters 1 and 2. The average number of cattle was 60.3 heads per herd, and producers were moving within a local territory during the dry season.

The fourth production system—which we refer to as "Transhumant Fulani zebu farms"—resembles cluster three in many features, including the ethnic group, the high number of zebu cattle, and the management system with a high amount of hired labour. The higher average

number of 217.7 heads per head conferred the owner a high place in the society and security of vicissitudes of life. However, the high number of cattle forced them to migrate beyond the national boundaries during the dry season regularly. Moreover, they kept their cattle far from settlements during the rainy season to prevent herds from causing damage to farmers' fields. This system was the most cattle market-oriented, with an average of 23.5 heads sold a year.

Across all four systems, cattle management was a family task, and men were widely considered having the primary responsibility for the cattle, supported by women and children. To different degrees, all family members were involved in feeding, watering, vaccination, and construction and cleaning of feedlots. Decisions regarding the purchase of cattle, feed supplements, and veterinary services were mostly the preserve of men. The men were also responsible for preventing animal theft, searching for lost animals, and for solving conflicts with other livestock keepers and farmers. Women were mostly in charge of calves, sick animals, small ruminants, watering animals, and milking. Breeding was not mentioned as a relevant task (FGD results).

The systems differed, however, regarding the distribution of labour. In "Sedentary Lobi taurine farms," family members were the main source of labour. In the "Sedentary crossbreed farms" cluster, Fulani laborers managed the cattle. Farmers hired the laborers and covered the costs related to animal treatment and feeding. In the FGDs, women participants of these groups emphasized that they do not consider the distribution of labour and income fair—their contribution to livestock production, including the provision of water in the dry season, was an addition to sustaining the family, while the control over cattle revenues remained with the men.

In the "Semi-transhumant Fulani zebu farms" system, cattle management was again a shared family task: herding was carried out by the owners and their children —particularly in Fulani households, in which all boys were herding after school. In this system, women were responsible for milking and milk processing as well as selling milk products. They also produced soap and butter for domestic use and sale. In contrast to women from sedentary farms, women participants in the FGDs of this group were not concerned by the question of sharing income fairly. However, while their husbands were satisfied with the division of labour, women in this group called for more support and appreciation by men.

In cluster four, "Transhumant Fulani zebu farms," the respondents were not directly involved in cattle management as cattle were kept far from the homestead. Laborers managed the cattle, and the owners visited the herds for follow-up only. In this system, women were not regularly involved in cattle production.

3.2. Constraints on cattle production

We summarize the identified constraints on cattle production in Table 4. In all production systems, farmers considered the lack of drinking water for animals, the lack of feed (pasture), and the pressure of diseases and parasites being the primary challenges. Further constraints were the high costs of veterinary drugs and the high mortality of young animals. In general, the number of constraints mentioned increased with the herd size of farmers. The individual perceptions were corroborated in the FGDs, and the participants across all systems considered

migration into the area, transhumance, and the growing population as main trends affecting agricultural production. Although water scarcity was frequently mentioned, this was attributed to the high demand rather than a changing climate. Owners of "sedentary Lobi taurine farms" and "sedentary crossbreed farms" suggested that they needed more knowledge to improve cattle management. Owners of "Semi-transhumant Fulani zebu farms" and "Transhumant Fulani zebu farms" found problems of damage on farmland and conflicts with farmers most constraining on their cattle production.

Table 4. *Primary constraints in cattle production in south western Burkina Faso (mean scores)*

Constraint	Sedentary Lobi taurine farms	Sedentary crossbreed farms	Semi-transhumant Fulani zebu farms	Transhumant Fulani zebu farms
Drinking water	3.33	3.42	3.72	3.89
Lack of pasture	2.9	3.24	3.58	3.75
Diseases and parasites	2.46	3.41	3.52	3.72
Damage on farmland	1.77	2.56	3.02	3.56
Conflict between farmers and breeders	1.3	2.43	2.8	3.43
Young animal mortality	2.05	2.16	2.84	3.21
Feed shortage	1.86	1.97	2.38	2.41
Theft or predators	2.37	2.13	2.02	2.55
High veterinary costs	1.97	2.27	2.38	2.5
Insufficient technical knowledge	2.34	2.22	1.94	1.45
High input costs	1.79	1.91	2.32	2.96
Marketing problems	1.42	1.88	2.04	2.27
Housing problems	2.06	2.03	2.04	2.07
Access to credits	1.38	2.16	1.98	1.5
Access to extension service	1.57	1.73	1.8	1.67

The study participants discussed adaptation pathways in the FGDs. Respondents whose primary occupation was livestock production considered a reduction of livestock density and an improved social organization of different agricultural activities in the region being the main adaptation pathways. Sedentary farmers, however, proposed to focus on the intensification of agricultural production.

IV. Discussion

4.1. Household characteristics

Age and literacy of household heads across the different production systems found by this study are in accordance with earlier work in the region (Soro et al., 2015; Mopaté et al., 2014). Any effort to fostering breeding programs in the region will need to take into account that the farming population is aging and mostly illiterate. Integrating their knowledge and experiences will be crucial to initiate any learning process for change. Earlier research has documented that literacy is a crucial factor in agricultural innovation (Adeleye et al., 2016).

Also, effective breeding efforts will have to resonate with the preferences and needs of a diversity of persons who have a role in cattle rearing: men as official decision-makers, but also women regarding milk production and processing, as well as hired herders.

4.2. Crop production

An increasing number of production risks confront smallholder agriculture in Sub-Sahara Africa, and agroecosystem diversification has been identified as a main buffer strategy (Altieri et al. 2015; Hänke and Barkmann., 2017; Gbegbelgbe et al., 2018). In our study, farm size, market prices and climate change were drivers for diversifying production systems—which is in agreement with earlier research in the region showing that farmers who own larger plots diversify into profitable cash crops (Ouédraogo et al., 2010; Audouin, 2014). Livestock keepers, who are often landless, tend to rent small parcels of land to build a homestead, grow some staple crops and build a kraal for small ruminants and dairy cattle (see Sanon et al., 2014). Considering that producers have different risk profiles and are generally risk-averse (Wiggins 2016), new breeding programs in the region should explicitly integrate risk management to increase the likelihood of participation.

4.3. Livestock production system

In earlier studies, production strategies and specific breeds were typically described in association with ethnic groups such as Lobi and Fulani (e.g. Mopaté et al., 2014; Soro et al., 2015; Dossa and Vanvanhssou 2016). We found, however, that the categorization based on ethnic groups has become less meaningful for tailoring interventions: the herd sizes of Lobi "Sedentary crossbreed farms" were similar to those on Fulani "Semi-transhumant Fulani zebu farms". Moreover, breed preferences have become less clear-cut: some sedentary farmers keep crossbred cattle for improved traction fitness and higher market value, and some semi-transhumant farmers recognized its superior resistance against diseases compared to pure Zebu cattle (see also: Mopaté et al. 2014; Sanon et al. 2014). In the literature, this dynamic is mainly attributed to a change in climate and increasing human migration: stocking herds as a savings strategy following favorable agricultural seasons has led to an increase in the number of zebu cattle in south-western Burkina Faso (INSD, 2014). Moreover, larger herds are more likely to be managed using transhumant strategies, as also found by Kaimba et al. (2011). Farmers with larger herds tend to employ herders, which may bring along cattle that are consequently crossbred with the herd owners' animals (Mopaté et al., 2014; Dossa and Vanvanhossou, 2016). Finally, the fact that breeding was not considered a task to be managed in livestock production

implies that interventions would first have to establish the benefits and costs of systematic breeding jointly with men, women and laborers.

4.4. Constraints on cattle production

Our study adds to the evidence that lack of drinking water for animals, the lack of feed (pasture), and the pressure of diseases and parasites are the primary challenges for livestock production in the region—as reported in previous studies (Soro et al., 2015, Koutou et al., 2017). Dossa and Vanvanhossou (2016) explained the decline of the Somba cattle population in Benin with the high mortality due to diseases, and feed and water shortage. According to Soudré et al. (2012) and Soro et al., (2015), trypanosomosis is a disease strongly reducing productivity in the region. Farmers, however, reported that over the past several years, the effect of foot and mouth disease has been even more adverse (Soudré et al. 2013). A likely contagion mechanism is transhumance during the dry season. In general, the identified constraints show the interlinkages of regional socio-ecological systems: the shortage of water has been explained by increased crop and cattle production in the region, as well as changing rainfall patterns. From 2006 to 2016, the farmed land in the region increased by 110 percent and cattle production increased by 31 percent (INSD, 2016; 2018). The high international demand for cashew nut has contributed to the intensification of agriculture (Audouin, 2014). Finally, the growing population in the region has further reduced the land available as pasture (Koutou et al. 2017). This shortage has likely increased conflicts between farmers and cattle keepers, who are competing for the same resources (Hellemans and Compere, 1990; Vall et al. 2006; Gonin and Tallet, 2012a, 2012b.). Our conclusion is that breeding programs need to adopt a systemic perspective to integrate meaningfully with current trends in the agroecosystem.

V. Methodology

The results of this study should be interpreted taking into account the limitations of survey research. First, we must assume that the sample is not fully representative of the farmer population in the area. Second, the perspective of the household head may not fully reflect the realities experienced by other household members. Third, in standardized questioning, respondents make assumptions about the meaning of questions and potential answers (Strack and Schwarz, 1992). These assumptions may lead to biases (e.g. social desirability).

We aimed to mitigate these limitations by (1), using a purposive sampling strategy to include the diversity of production systems, while not concluding on the quantitative ratio of the different types; by (2), complementing the household survey with FGDs to integrate the perspective of women and to validate the survey findings.

VI. Conclusion

The purpose of this study was to understand cattle production systems in south-western Burkina Faso, given the importance of the sector for livelihoods and the endangerment of the local Lobi taurine breed. We identified four distinct types of production systems: 1) Sedentary Lobi farms, 2) Sedentary crossbreed farms, 3) Semi-transhumant Fulani zebu farms, and 4) Transhumant Fulani zebu farms. While Lobi taurine and crossbred animals continue to fulfill different livelihood and cultural roles, Lobi farmers have started to invest in cattle rearing as a

complementary livelihood strategy. Fulani pastoralists have started to engage in crop production and continuous local marketing of animal products. Accordingly, traditional categories of "Lobi Famer" and "Fulani Livestock Keeper" do not fully reflect the reality of the sector—future preservation and breeding efforts must take this transition into account. Moreover, all identified production systems are increasingly confronting disease pressure and scarcity of water and land. Cattle breeding programs will need to respond to these trends in the agroecosystem, integrate risk management measures, and resonate with the specific needs of the different household members involved in cattle rearing.

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VII. References paper I

Adeleye, O., J.K. Alli-Balogun, O.G. Afiemo and S. Bako. 2016. Effects of goat production on the livestock of women in Igabi, Chikun and Kajuru Local Government Areas, Kaduna State, Nigeria, Asian Journal of Agricultural Extension, Economics and Sociology, 11, 1-8.

Altieri, M.A., C.I. Nicholls, A. Henao and M.A. Lana. 2015. Agroecology and the design of climate change-resilient farming systems Agronomy for Sustainable Development, 35, 869–890.

ANAM. 2017. Rapport annuel des statistiques, (Agence National de la Météorologie/Direction Provincial de Gaoua, Burkina Faso).

Audouin, S. 2014. Systèmes d'innovation et territoires : un jeu d'interactions ; Les exemples de l'anacarde et du jatropha dans le sud-ouest du Burkina Faso, (PhD thesis, University of Paris I- Pantheon-Sorbonne).

Coulibaly, M. 1989. Systèmes d'élevage et productivité du cheptel bovin en pays Lobi (Burkina Faso), (Mémoire DESS. IEMVT, Maison Alfort), 85 p.

Dayo, G-K. 2009. Recherche de marqueurs génétiques associés à la tolérance et/ou sensibilité des bovins aux trypanosomes africaines, (Thèse Doctorat d'université, Université Montpellier II), 164p.

De la Rocque S., J.F. Michel, D. Cuisance, G. De Wispelaere, P. Solano, X. Augusseau, M. Arnaud, S. Guillobez. 2001. Du satellite au microsatellite. Le risque trypanosomien. Une approche globale pour une décision locale, (CIRAD, Montpellier), 151p.

Dossa L.H., C. Wollny, M. Gauly, I. Gbégo. 2009. Community-based management of farm animal genetic resources in practice: framework for local goats in two rural communities in Southern Benin, Animal Genetic Resources, 44, 11– 31.

Dossa, L.H., and F.U.S. Vanvanhossou. 2016. The indigenous Somba cattle of the hilly Atacora region in North-West Benin: threats and opportunities for its sustainable use, Tropical Animal Health and Production, 48, 349-359.

Duguma G., T. Mirkena, A. Haile, A.M. Okeyo, M. Tibbo, B. Rischkowsky, J. Sölkner, M. Wurzinger. 2011. Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: choice model approach, Animal, 5, 1984–1992.

FAO. 2010. Breeding Strategies for Sustainable Management of Animal Genetic Resources; FAO Animal Production and Health Guidelines. No 3.; FAO: Rome, Italy, p. 132. Available online: http://www.fao.org/3/i1103e/i1103e.pdf (accessed on 17 April 2018).

FAO 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Rome, Italy: FAO Commission on Genetic Resources for Food and Agriculture Assessments. 12p. Available online: http://www.fao.org/3/i5077e/i5077e.pdf (Accessed on 20 April 2018).

FAO. 2018. Le dévelopement durable de l´élevage africain: approche «Une seule santé » au Burkina Faso. Rome, Italy, 104p. Available online: http://www.fao.org/3/ca1084fr/ca1084fr.pdf (Accessed on 13 january 2019).

Gbegbelegbe, S., J. Serem, C. Stirling, F. Kyazze, M. Radeny, M. Misiko, S. Tongruksawattana, L. Nafula, M.Gakii. and Sonder, K., 2018. Smallholder farmers in eastern Africa and climate change: a review of risks and adaptation options with implications for future adaptation programmes, Climate and Development, 10, 289–306.

Gonin, A. and B. Tallet. 2012a. Changements spatiaux et pratiques pastorales: les nouvelles voies de la transhumance dans l'Ouest du Burkina Faso, Cahiers Agricultures, 21, 6, 448-454.

Gonin, A. and B. Tallet. 2012b. Quel avenir pour l'élevage dans le bassin cotonnier de l'Ouest du Burkina Faso? Dynamiques agro-pastorales et recompositions territoriales, Autrepart, 60, 1, 95-110.

Haile, A., T. Mirkena, G. Duguma, M. Wurzinger, B. Rischkowsky, M. Tibbo, M. Okeyo, and J. Sölkner. 2013. Community based sheep breeding programs: Tapping into indigenous knowledge, Livestock Research for Rural Development, 25, 219.

Hänke, H. and J. Barkmann. 2017. Insurance function of livestock, Farmers coping capacity with crop failure in southwestern Madagascar World Development, 96, 264–275.

Hellemans P., and R. Compere. 1990. Aspects techniques et socio-economiques de la transhumance des troupeaux de zebus en zone soudanienne de la Bougouriba (Burkina Faso), Tropicultura, 1990, 8, 2, 59-83.

INSD, 2014. Annuaire Statistique du Burkina Faso. Institut National de la Statistique et de la Démographie, Ministere de l´Economie et des Finances. Ouagadougou: Burkina Faso. Available online: www.insd.bf/contenu/pub_periodiques/annuaires_stat/Annuaires_stat_nationaux_BF/Annuaire_stat_2014.pdf (accessed on 24 October 2019).

INSD, 2016. Annuaire Statistique du Burkina Faso. Institut National de la Statistique et de la Démographie, Burkina Faso, Ministere de l´Economie et des Finances. Ouagadougou: Burkina Faso. Avalaible online: http://www.insd.bf/contenu/pub_periodiques/annuaires_stat/Annuaires_stat_nationaux_BF/Annuaire_stat_2016.pdf (accessed on 24 October 2019

INSD. 2018. Annuaire statistique. Institut National de la Statistique et de la Demographie, Ministere de l´Economie et des Finances. Ouagadougou: Burkina Faso. Available online: http://www.insd.bf/n/contenu/pub_periodiques/annuaires_stat/Annuaires_stat_nationaux_BF/Annuaire_Statistique_National_2018.pdf (accessed on 15 November 2019).

Jahnke, H.E., 1982. Livestock production systems and livestock development in tropical Africa. (Kieler Wissenschaftsverlag Vauk, Germany), 241p.

Jolliffe I.T. 1986. Principal Components in Regression Analysis. In: Principal Component Analysis. Springer Series in Statistics. Springer, New York, NY. https://doi.org/10.1007/978-1-4757-1904-8_8

Kaboré, M. 2012. Etude de la diversité génétique des taurins Baoulé du Burkina Faso a l'aide de marqueurs microsatellites, (DEA thesis, University of Ouagadougou).

Kaimba, G.K., B.K.Njehia, A.Y.Guliye. 2011. Effects of cattle rustling and household characteristics on migration decisions and herd size amongst pastoralists in Baringo District, Kenya, Pastoralism: Research, Policy and Practice, 1.

Koutou, M., M. Sangaré, M. Havard, E. Vall, L. Sanogo, T. Thombiano, D.S. Vodouhe. 2017. Adaptation des pratiques d'élevage des producteurs de l'Ouest du Burkina Faso face aux contraintes foncieres et sanitaires, Agronomie Africaine, 28, 2, 1-87.

Kruska R.L., R.S. Reid, P.K. Thornton, N. Henninger, P.M. Kristjanson. 2003. Mapping livestock-oriented agricultural production systems for the developing world, Agricultural Systems, 77, 39– 63.

MAHRH. 2011. Cadre d'action pour l'investissement agricole au Burkina Faso. (Ministère de l`Agriculture, de l´Hydraulique et des Ressources Halieutiques Burkina Faso, Ouagadougou), 88p.

MAHRH/GTZ. 2014. Mission d'appui à l'identification des interventions du Programme de Développement de l'Agriculture de la Coopération germano-burkinabé dans la région administrative du Sud-Ouest. Ouagadougou, (Ministère de l´Agriculture, de l´Hydrauliques et des Ressources Halieutiques Burkina Faso & Deutsche Gesellschaft für Technische Zusammenarbeit).

MEF/DREP. 2014. Profil régional 2013 du Sud-Ouest, (Ministère de l'Economie et des Finances/Direction Régionale de l'Economie du Sud-Ouest, Burkina Faso).

Mirkena T., G. Duguma, A. Willam, M. Wurzinger, A. Haile, B. Rischkowsky, A.M. Okeyo, M. Tibbo, J. Sölkner. 2012. Community-based alternative breeding plans for indigenous sheep breeds in four agro-ecological zones of Ethiopia, Journal of Animal Breeding and Genetics, 129, 244-253

Mopaté, L.Y., M.J-B. Kamuanga, S. Hamadou and C-Y. Kaboré-Zoungrana. 2014. Evaluation des pratiques paysannes de conservation in situ du taurin Baoulé au Sud-Ouest du Burkina Faso, Animal Genetic Resources, 54, 171-178.

Mueller J.P., 2013. Experiencias con estructuras genéticas para el mejoramiento de rumiantes menores en las zonas áridas. In: L.R. Iñiguez (eds.), La Producción de Rumiantes Menores en las Zonas Áridas de Latinoamérica, (EMBRAPA, Brasília), 497–513.

Nimbkar, C., P.M. Ghalsasi, S.W. Walkden-Brown, L.P. Kahn. 2002. Breeding program for the genetic improvement of Deccani sheep of Maharashtra, India: In: Proceedings of the 7th World Congress on Genetics Applied to Livestock Production, Montpellier/France, 2002.

Ojango J.M.K., C. Ahuya, A.M. Okeyo, J.E.O. Rege. 2010. The FARM-Africa dairy goat improvement project in Kenya: a case study. In: J.M. Ojango, B. Malmfors, A.M. Okeyo (eds), Animal Genetics Training Resource, (International Livestock Research Institute, Nairobi, and Swedish University of Agricultural Sciences, Uppsala).

Ouédraogo, M., Y. Dembélé, L. Somé. 2010. Perceptions et strategies d'adaptation aux changements des preécipitations: cas des paysans du Burkina Faso, Sécheresse 21, 2, 87-96.

Robinson T.P., G.W. Wint Conchedda, T.P. Van Boeckel, V. Ercoli, E. Palamara, G. Cinardi, L. D'Aietti, S.I. Hay, M. Gilbert. 2014. Mapping the global distribution of livestock. PLoS ONE, 9, e96084. https://doi.org/10.1371/journal.pone.0096084

Sanon, H. O., M. Savadogo, H.H. Tamboura and B.A. Kanwé. 2014. Caractérisation des systèmes de production et des ressources fourragères dans un terroir test de la zone soudanienne du Burkina Faso, VertigO-La revue électronique en sciences de l'environnement, 14, 2.

Scherf, B., M. Tixier-Boichard. 2009. Production environment recording. Animal Genetic Resources, 44, 7– 10.

Sicot, O., 1993. Importane socio-économique du cheptel bovin dans la province du poni (Burkina Faso), (Mémoire DESS. IEMVT, Maison Alfort), 59 p.

Sokouri D.P., C.V. Yapi-Gnaore, A.S.P. N'Guetta, N.E. Loukou, B.J. Kouao, G. Toure, A. Sangare et A. Kouassi. 2009. Utilisation et gestion des races taurines locales sous la pression des croisements avec les zébus dans les régions Centre et Nord de la Côte d'Ivoire, Journal of Animal & Plant Sciences. 5/2, 456 – 465.

Sölkner, J., H. Nakimbugwe, and A. V. Zárate. 1998. Analyses of determinants for success and failure of village breeding programmes. In: Proceedings of the Sixth World Congress on Genetics Applied to Livestock Production, Armidale/Australia, 1998.

Soro B., D.P. Sokouri, G.K. Dayo, A.S.P. N'Guetta and C.V. Yapi Gnaoré. 2015. Caractérisation des bovins de race Baoulé dans le "Pays Lobi" de Côte d'Ivoire: rôles socioéconomiques, modes d'élevage et contraintes de production, Tropicultura, 33, 2, 111-124.

Soudré A., S. Ouédraogo-Koné, M. Wurzinger, S. Müller, O. Hanotte, A.G. Ouédraogo, J. Sölkner. 2013. Trypanosomosis: a priority disease in tsetse-challenged areas of Burkina Faso, Tropical Animal Health and Production, 45, 3, 497-503.

Sow, A., I. Sidibé, M. Kamuaga, J-C. Maillard, C. Ly. 2005. Epidémiologie et importance socio-économique de la dematophilose dans les élevages bovins du pay lobi (Sud-ouest du Burkina Faso), Revue Africaine de Santé et de Productions Animales, 3/1, 15-22.

Steinfeld H. 1997. Interactions bétail – environnement en Afrique humide et subhumide: éléments sous-jacent et politiques recommandées. In : Politique pour le développement de l'élevage en zones humides et subhumides de l'Afrique subsaharienne : actes du séminaire tenu à Abidjan, Côte d'Ivoire, du 05 au 09/02/96, Wageningen, Pays-Bas, Cta, p. 87-107.

Strack, F., and N. Schwarz. 1992. Communicative influences in standardized question situations: The case of implicit collaboration. In : K. Fiedler and G. Semin (eds), Language and social cognition, (Cambridge University Press : Cambridge, UK).

Tano, K., M.J.B. Kamuanga, M.D. Faminow, B.M. Swallow. 2001. Adoption and demand for trypanotolerant cattle in the subhumide zone of West Africa, Journal of Agriculture and Environment for International Development 95(2–3), 213–235.

Tibshirani R, G. Walther, T. Hastie. 2001. Estimating the number of clusters in a data set via the gap statistic. Journal of the Royal Statistical Society B, 63, 2, 411-423.

Vall, E., P. Dugué, M. Blanchard. 2006. Le tissage des relations agriculture-élevage au fil du coton, 1990-2005, Cahiers Agriculture, 15, 1, 72-79.

Wiggins, S. 2016. Risk aversion among smallholder farmers in Uganda, (ODI: London).

Wurzinger M., A. Willam, J. Delgado, M. Nürnberg, A.V. Zárate, A. Stemmer, G. Ugarte and J. Sölkner. 2008. Design of a village breeding programme for a llama population in the High Andes of Bolivia, Journal of Animal Breeding and Genetics, 125, 311– 319.

Wurzinger, M., J. Sölkner, and L. Iniguez. 2011. Important aspects and limitations in considering community-based breeding programs for low-input smallholder livestock systems, Small Ruminant Research, 98:170–175.

Wurzinger, M., L. Escareno, F. Pastor, H. Salinas, and J.Sölkner. 2013. Design and implementation of a community-based breeding program for dairy goats in northern Mexico, Tropical and Subtropical Agroecosystems, 16, 2, 289–296.

Yapi-Gnoaré, C.V. 2000. The open nucleus breeding programme of the Djallonké sheep in Côte D'Ivôire. In: Galal, S., Boyazoglu, J., Hammond, K. (eds.), Workshop on Developing Breeding Strategies for Lower Input Animal Production Environments, Bella/Italy, 1999.

CHAPTER III

Values and beliefs that shape cattle breeding in south-western Burkina Faso

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Abstract

Cattle production in south-western Burkina Faso is under pressure by the scarcity of resources, the changing climate, and cattle diseases. Well-adapted local breeds, such as the Lobi taurine cattle, are increasingly replaced by more productive exotic breeds. Community-based breeding programs (CBBPs) could be a viable option for preserving the breed and improving its productivity. Presuming that CBBPs would only succeed when resonating with producers' beliefs and values, we relied on a combination of conceptual frameworks (theory of basic values, rural livelihood transitions) to explore the values and beliefs of cattle producers. *Security* was the respondents' dominant value as they aim to mitigate livelihood risks, closely linked to *achievement* in terms of harvest and animal quantity. Particularly livestock-oriented respondents valued *conformity* with accepted social roles, while *achievement* and *power* were more pronounced among crop-oriented respondents. We conclude that a successful CBBP will need to reduce livelihood risks for participants and make benefits of participation immediately visible. To create momentum for novel cattle-keeping and feeding arrangements, we consider trusted leadership emerging from the community as pivotal.

Keywords: values, beliefs, cattle breeding, Burkina Faso

Introduction

I. Community-based breeding to improve smallholder livelihoods

Agriculture remains the primary source of livelihoods for the majority of smallholders who live in rural areas of the Global South (McIntyre et al. 2009). These livelihoods are challenged by the accelerating climate crisis, societal dynamics and degrading natural resources (Alvaredo et al. 2018; Cherlet et al. 2018; IPCC 2019).

To address the resulting food security challenges, farmers have continuously adapted their practices, also in south-western Burkina Faso, the focus area of this study (e.g. Reij et al. 2009). In the area, cattle keeping is an essential part of agriculture-based livelihood strategies, and local breeds are part of traditions, fulfilling social, cultural and spiritual roles (e.g. FAO 2013). While local cattle breeds can contribute to the resilience of livestock-oriented livelihoods through their particular suitability to the specific environment, robustness and tolerance to diseases, livestock keepers have reduced their number in favour of "exotic" or crossbreed animals – whose productivity and market value tends to be higher (Leroy et al. 2015). In our study area specifically, the indiscriminate crossbreeding of local Lobi taurine cattle with Fulani Zebu threaten the survival of Lobi taurine: recent studies have confirmed the decline in the number of heads (e.g. Mopaté et al. 2014).

Figure 1 A herd of Lobi taurine and Fulani Zebu crossbreed cattle grazing in Bouroum-Bouroum. Photo: B.Z.-T.

Eventually, such decline can lead to the extinction of local cattle breeds, threatening both local livelihood resilience and the conservation of important animal genetic resources. The Food and Agriculture Organization (FAO) (2013; 2015) has classified most local cattle breeds as endangered and recommends in vivo and in situ conservation through sustainable management and the establishment of breeding programs. In the context of low-input smallholder systems, community-based breeding programs (CBBPSs) have emerged as a strategy to conserve and improve local breeds (e.g. Mueller et al. 2015). CBBPs are an attempt to bring together livestock keepers, scientists and other stakeholders – with the objective to jointly improve and share genetic resources. In contrast to conventional breeding programs, CBBPs focus on local genetic resources and farmer cooperation. Establishing locally relevant institutions can further facilitate joint marketing and collaboration beyond breeding. As an approach, CBBPs depend strongly on resonating with the livestock keepers' needs to ensure commitment and participation (Mueller et al. 2015). While some earlier work on CBBPs has addressed questions of livestock keepers' knowledge, perceptions, and choices (e.g. Wurzinger & Gutierrez, 2017; Martin-Collado et al. 2018), the focus in the literature has been mostly on technical aspects of breeding (e.g. selection criteria, exchange of breeding males). The purpose of this study is, therefore, to understand the values and beliefs that shape choices by cattle keepers in south-western Burkina Faso. From this understanding, we aim to derive insights that are practically relevant for facilitators of CBBPs.

II. Agricultural innovation in smallholder contexts

Increasing productivity, income, food security, and reducing poverty has been the purpose of interventions and research for development for many decades (e.g. Kassie et al. 2011). In smallholder contexts, changing agricultural practices (including livestock breeding) has been a common strategy to pursue these outcomes. The conventional perspective proposed that change is the result of the transfer of technology and innovation diffusion (see Röling 2009 for a summary). The main actors in this concept are research and extension organizations, while farmers are expected to learn and adopt novel technologies (Jarrett 1985). Chambers et al. (1989), amongst others, criticized this conceptualization, and stressed the agency of farmers and proposed to put "Farmers first" in experimenting with new technologies. These ideas were taken up by more recent approaches that included institutional, contextual and individual dimensions of change in agricultural practices such as Agricultural Knowledge and Information Systems (AKIS) and Farming System Research (FSR) (e.g. Norman 2002). Currently, mainstream approaches understand the change in agricultural practices as an emerging property of Agricultural Innovation Systems (AIS), consisting of actors, their interactions and institutions (Klerkx et al. 2012). Accordingly, creating a condensed innovation system through a multi-stakeholder process is expected to create more legitimate, sustainable and contextualized outcomes. The implementation of such processes varies and is strongly determined by the institutional embedding (Schut et al. 2016). In parallel to these process-oriented approaches, deterministic concepts of adoption remain common, including in the study region of this work (e.g. Jahel et al. 2018). At a fundamental level, adoption studies assume rational individual choices constrained by external factors – this assumption has been questioned by many studies which established that farmer decision making is also grounded in values, norms and meanings individuals 'construct' in relation to agricultural practices (e.g. Bassi et al. 2019; Meijer et al. 2015).

Then again, the recent 'ontological turn' in rural sociology asks whether the focus on human cognition and agency in the constructivist tradition is sufficient to understand the constantly evolving, unpredictable "tissue of interactions" in agricultural practice (Darnhofer 2020). While we acknowledge this recent turn, our approach is mostly rooted in the constructivist understanding of 'meaning-making', which we consider essential in transdisciplinary research for development. We chose the concepts to frame our analysis accordingly.

III. Theoretical framework: values and beliefs

Inquiries into why farmers do what they do are a recurring theme in transdisciplinary research for development, including livestock keeping and breeding (e.g. Bassi et al. 2019). A range of theories has been applied to understand and predict behavior, and most widely, the Theory of Planned Behavior (TPB) (Ajzen 1991). TPB posits that an individual's intention is the best predictor of behavior, and that intention is determined by attitude, norms and perceived behavioral control. Borges et al. (2016), relied on TPB to model cattle management decisions of Brazilian farmers. O'Kane et al. (2017) extended on TPB to investigate farmer behavior confronting sheep footrot. De Lauwere et al. (2012) applied TPB to understand farmers'

decisions regarding sow housing. Like other expectancy-value theories, TPB is most useful when intentions regarding a specific, proposed behavior are analyzed. Considering the objective of our study (to understand the values and beliefs that shape choices by cattle keepers), we sought to apply a framework that would allow to us to *openly* explore the farmers' values and beliefs regarding their livelihoods and cattle breeding. To do so, we referred to Schwartz' (1992) theory of basic values, as it transcends specific actions or situations and investigates the *relative* importance of values and their trade-offs. The theory has been applied and discussed since the 1980s, being particularly influential in consumer studies. In the agricultural context, examples of successful application include farmer mental models of change in Sweden (Hansson and Suvi 2018), farmer water conservation practices in the US (Pradhananga and Davenport 2019), and value orientation confronting climate change in Ethiopia (Etana et al. 2020).

Schwartz' theory of basic values positions values along two bipolar dimensions: *openness to change/conservation* and *self-enhancement/self-transcendence*. Within these dimensions, the theory specifies ten values. Initially, Schwartz (1992) developed a research instrument which asked the respondents to rate the importance assigned to a specific value directly. In the expansion of the basic values theory, Stern et al. (1999) proposed that values affect beliefs, which can turn into norms and actions (Value-belief-norm theory). While such clear sequential chains have been disputed in behavioural research, the existence of *formal* links is widely accepted. We therefore posit that respondents' belief statements, or propositions about what is and why, are indicative of their respective values.

IV. Analytical framework

We developed an analytical framework to link the theoretical considerations to the specific research case at hand. To structure our investigation according to aspects of the livestock keepers' livelihoods, we referred to the concept of rural livelihood transitions (El Bilali et al. 2017) and distinguished between landscape, regime, and livelihood strategies. We also specified the ten basic values based on Schwartz' (1994) "conceptual facets". The analytical framework later served as the coding frame in the deductive coding phase of the data.

Table 1 Analytical framework based on El Bilali et al. (2017) and Schwartz (1994)

Domain	Subdomain	Description
Landscape		larger-scale trends in the agro-ecosystem that cannot be directly influenced at individual or community level
Regime		established societal practices and accepted rules
Livelihood strategies		assets and strategies used to achieve livelihood outcomes
Values	*Security*	Personal and societal security, experienced as safety, harmony and stability
	Power	Social status and prestige, control over people or resources
	Achievement	Success through demonstrating competence according to social standards
	Hedonism	Pleasure and gratification for oneself
	Stimulation	Excitement, novelty and challenge in life
	Self-direction	Independent thought and action
	Universalism	Understanding and protection of welfare for all people and for nature.
	Benevolence	Caring for people with whom one is in frequent contact
	Conformity	Following societal expectations and norms

V. Materials and methods

5.1. Study sites and sampling

The research was conducted in the south-western region of Burkina Faso, which is located in the mountainous South-Sudanian ecological zone (Fig.2). Mean annual rainfall ranges from 900 to 1200 mm, and mean monthly temperatures range from 21 to 32°C. Different ethnic groups compose the population of about 850.000 people: Lobi, Dagara, Birifo, Djan, and Pogouli who are considered "local", and Mossi, Fulani and Bobo who are considered immigrants (INSD 2018). The population is growing with a rate of about 4.5%, including net immigration of about 2% (INSD 2018). Cattle and crop production are the primary economic activities in the area (Ouédraogo et al. 2019).

We collected data in the administrative units of Bouroum-Bouroum, Kampti, and Loropeni in the Poni province. Typically for the region, crop and cattle production are growing through increases in farmed area and stocking density (INSD 2018). At the same time, rainfall patterns have become erratic, and parasite and disease pressure constrain livestock production (Zoma-Traoré et al. 2020).

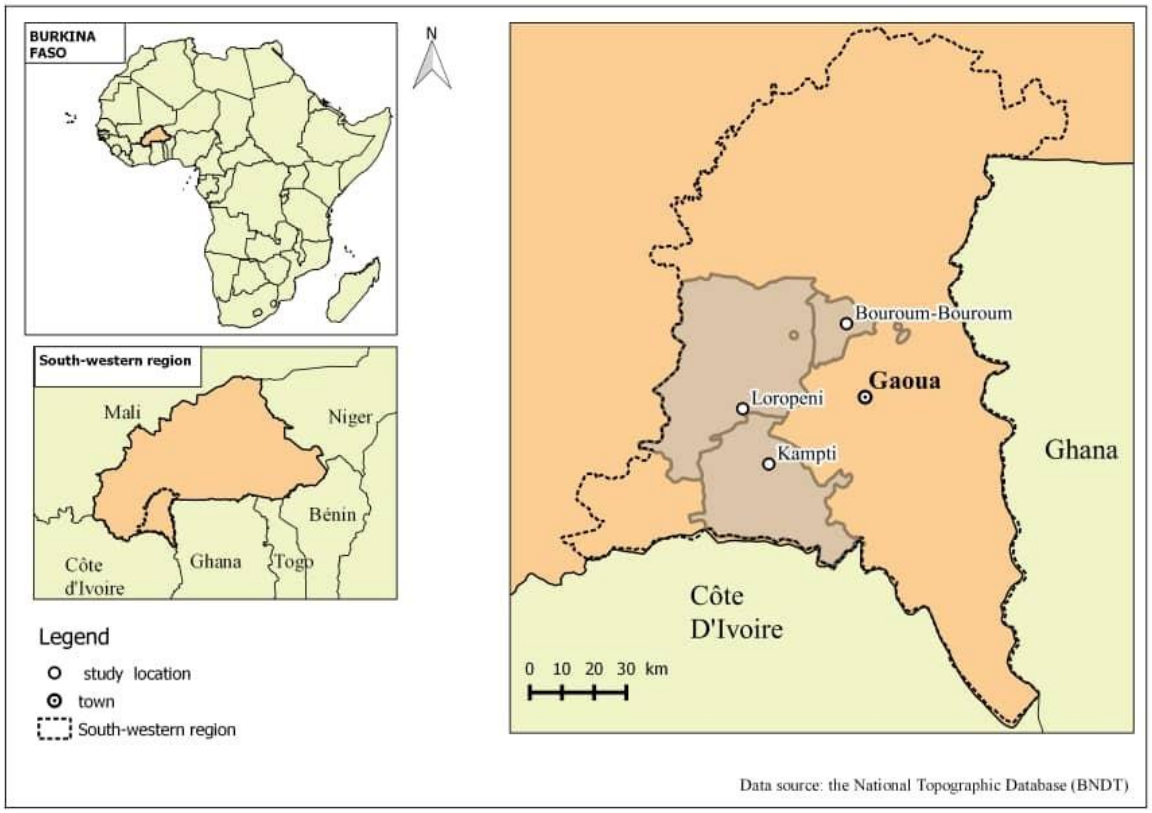

Figure 2 Location of the study sites

In an earlier study conducted at the study sites (Zoma-Traoré et al. 2020), we developed a typology of cattle production systems based on a sample of 169 households in the region. The analysis identified four distinct systems (Table 1). For the present study, we randomly sampled respondents from each system to capture the diversity of cattle production systems while maintaining a number that would allow for in-depth conversation and analysis. Two additional households from Clusters II and III had been randomly sampled for testing the research instrument, and since we did not change the instrument after testing, we retained the data for analysis (total n=34).

Table 2 Characteristics of sampled respondents and production systems (for the analysis, see Zoma-Traoré et al. 2020)

	Sedentary Lobi taurine farms (Cluster I)	**Sedentary crossbreed farms (Cluster II)**	**Semi-transhumant Fulani zebu farms (Cluster III)**	**Transhumant Fulani zebu farms (Cluster IV)**
Characteristics of production system	Focused on crop production, with a low number of cattle (predominantly Lobi taurine). Cattle herded in the rainy season, free grazing after the crop harvest and during the dry season. Cattle are sold only in case of urgent financial needs.	Focused on crop production, but cattle are important as savings and insurance, draught animals, and providers of manure. The majority of cattle are crossbred. Animals herded throughout the year, and are not sold regularly.	Focused on milk and meat production for the market, with limited crop production for subsistence. Cattle are sold regularly, and herds move within a local territory during the dry season.	Cattle market oriented system with a high number of cattle that are kept far from settlements during the rainy season to avoid conflicts. Transhumance beyond national borders during the dry season.
Sampled respondents	8 heads of household (all male)	9 heads of household (all male)	9 heads of household (all male)	8 heads of household (all male)
Age (years: mean (SD))	50.25 (7.74)	51.89 (9.68)	48.77 (16.41)	48.13 (11.51
Literacy of household head (%)	25.00	44.44	22.22	0.00
Number of cattle (mean (SD))	35.88 (23.58)	32.78 (25.88)	36.44 (23.89)	156.13 (62.55)
Cropland area (ha: mean (SD))	13 (4.84)	13.44 (3.64)	6.67 (4.42)	7.24 (4.19)

5.2. Research instrument

The interviews were moderately structured by a guide based on the analytical framework. The question of how theory-language can be translated into conversations that yield useful material for analysis has been discussed for many years. We used the strategy of indirection (Wrigley 2001) to design questions that would prompt a conversation indicating respondents' beliefs. Being aware of the ethical concerns related to indirection, the interviewer carefully explained to respondents that we would look at their descriptions and argumentations to understand how and why they took decisions related to their livelihoods in general and cattle breeding in particular. For example, the question: *"When you tell your friends/family members about a successful year as a farmer/cattle keeper, what do you mention?"* was used to initiate a discussion about the respondent's livelihood and related challenges, while at the same time yielding belief statements on the definition of success. These statements, in turn, contained rich evidence on what is valued by the respondent (e.g. *security, achievement*).

5.3. Data collection and analysis

The first author contacted the heads of the sampled households and asked whether they would be willing to share their insights into the realities of agriculture and cattle breeding in more detail. All 34 individuals contacted agreed to participate in the study. Before starting the interviews, we obtained free prior and informed consent from each respondent, including the permission to audio-tape the interviews. The respondents chose time, place and language (Dioula, Mooré, French) used for the interview.

The first author transcribed the interviews, and if necessary, translated to French. We analyzed the transcripts using a combination of deductive coding following the analytical framework (e.g. values, livelihood descriptions) and inductive coding (e.g. recurring belief statements). We coded the data in atlas.ti Cloud, which allowed the research team to increase inter-coder reliability by working in parallel and discussing divergent interpretations. For detailed analysis (occurrence frequency, code co-occurrence) following the research questions, we exported the hermeneutic unit to atlas.ti 8 for Windows. In the results, cited quotations are labelled with respondent and quotation number (QX:XX), respondent cluster, place and date of the interview.

Differences in the values between the four clusters were compared using Chi-Square test followed by pairwise comparisons with Bonferroni adjustments for multiple testing. Statistical differences were considered significant at $p<0.05$. Spearman´s rank correlation analysis was applied to analyze the associations of the different values separately for crop-oriented clusters (I and II) and livestock-oriented clusters (III and IV).

VI. Results

We report the results following the dimensions of the conceptual framework, assuming that respondents' values and beliefs are being shaped by and shaping their livelihoods. We begin with the livelihood descriptions, followed by the analysis of values expressed through belief statements.

6.1. Livelihood description

Landscape level

The increasing scarcity of land and resources emerged as the critical livelihood dynamic observed by respondents. The influx of migrants from neighboring regions and the changing rainfall patterns have led to growing competition over land and water for cattle and crop production, as explained by respondent 15:

> *"There is no pasture now, there is no space. Space is limited, people have become numerous, the pastures have become small." (Q15:85, Cluster IV, Loropéni, 20.08.2019)*

The respondents considered the weather-dependence of agriculture and cattle production the main risk factors affecting their livelihoods – accordingly, respondents across all clusters mentioned sufficient and timely rainfall as the main attribute of a successful year:

> *"For example, if it doesn't rain well during the month of August and the following months, we say that it has not rained well and that the year will not be good. So, the year depends mostly on rain." (Q20:37, Cluster IV, Kampti, 23.07.2019)*

In livestock production, the occurrence of diseases was an additional challenge which producers felt they had little control over. Overall, many respondents strongly expressed their belief in the power of God in setting the course for their livelihoods, for example respondent 26:

> *"Ah, it is God who has decided it! Because God created you, what he wants you to do, this is what you will do." (Q26:97, Cluster II, Loropéni, 02.10.2019)*

Regime level

Concerning cattle production in particular, the livelihoods of respondents were characterized by a weak institutional framework, as theft of animals frequently occurred (see Q7:24 below) and veterinary services were difficult to access and afford.

> *"But right now, there are many thieves; if you leave the cattle like this, you will not even have a single animal after, they will steal." (Q7:24, Cluster I, Bouroum-Bouroum, 25.07.2019)*

Animal breeding was not institutionalized at the time of the study. While cattle production is market-oriented, market volatility made it difficult for producers to strategically market cattle products.

Livelihood and cattle breeding strategies

Across all clusters (Table 2), the respondents considered diversification the most promising strategy to achieve livelihood outcomes. Respondents whose principal activity was crop farming diversified their crop portfolio, typically by investing in cashew growing. Livestock keepers expanded subsistence-oriented crop production. Respondents from all groups were seeking to engage in non-farm activities such as trading and building. However, respondents widely considered agriculture (including crop and livestock production) as being the backbone of their livelihood:

> *"Whether you are a minister or the president, you have to have a field." (Q33:13, Cluster IV, Loropeni, 02.09.2019)*

Respondents from sedentary clusters (I and II) considered the education of the next generation as their main investment strategy, while respondents from transhumant clusters (III and IV) expanded trading and construction activities.

Considering the motivation of this study (providing insights that are practically relevant for facilitators of CBBPs), we put a particular focus on the respondents' breeding strategies in the interviews. Across all clusters, the standard strategy was to select and keep one dominant mating bull with the herd, as well as two to three smaller bulls as a backup. Owning a bull was generally seen as a sign of achievement. Due to the proximity of enclosures and free-roaming of cattle during the dry season, respondents agreed that random breeding is the common practice and unavoidable. The respondents also stressed the advantage of not having to monitor the heat of cows in this system, for example respondent 20:

"A cow can get up one night and be in heat – so what happens if you have given your bull away? This is why the male is left permanently in the herd so that he can mount the females at any time." (Q20:30, Cluster IV, Kampti, 23.07.2019)

Corresponding to the above perceptions, we could not find any evidence for organized breeding, e.g. through bull sharing, in the study sites. When reflecting on opportunities for community-based breeding, respondents were concerned about the related risks and costs of sharing animals: others may not treat animals well, or accuse someone of not treating the animal well; animals may get lost or stolen; transporting a bull beyond the immediate neighborhood would be too expensive.

Finally, some respondents (e.g. respondent 20 below) questioned the possibility of improving cattle traits through continuous breeding, suggesting that real improvement would require bringing in animals from abroad:

"Unless it's a bull of a breed from somewhere else, the bulls that are here are the same, (...) we don't want to put them in our herds anymore. (...). You know that if the bulls are not of different breeds, no, no, we don't say that this bull is better than the other, no, no, no." (Q20:40, Cluster IV, Kampti, 23.07.2019)

6.2. Respondent values and beliefs

Following the theoretical considerations of this study, we presume that values operate as a formal backdrop of principles when cattle producers make choices. Considering our research interest (understanding the values and beliefs that shape choices by cattle keepers), we report in detail on the five values with the highest frequency of occurrence in the hermeneutic unit (Fig. 3). Belief statements indicating the value *security* occurred most often, followed by *achievement* and *conformity*, and at some distance *power* and *self-direction.*

Security

Security emerged as the first (cattle-oriented clusters III and IV) and second (crop-oriented clusters I and II) most important value from the interviews. Between-group differences were not significant (Table 3). The respondents expressed security-related beliefs mostly in relation to the insecure livelihood situation due to larger-scale trends and the lack of risk mitigation and management. As illustrated above and described by respondent 31, the livestock keepers reacted at the household level by diversification of livelihood strategies and by the accumulation of savings.

"There is a proverb that says: "a single axe cannot cut down the tree". It takes several sharp axes to cut down a tree. Today, if you focus on cattle only, there will be times when diseases can come and ravage your herd – then what are you going to sell? So I tell myself that the two activities have to go hand in hand. I do crop farming and then a little bit of cattle keeping". (Q31:1, Cluster I, Loropéni, 29.08.2019)

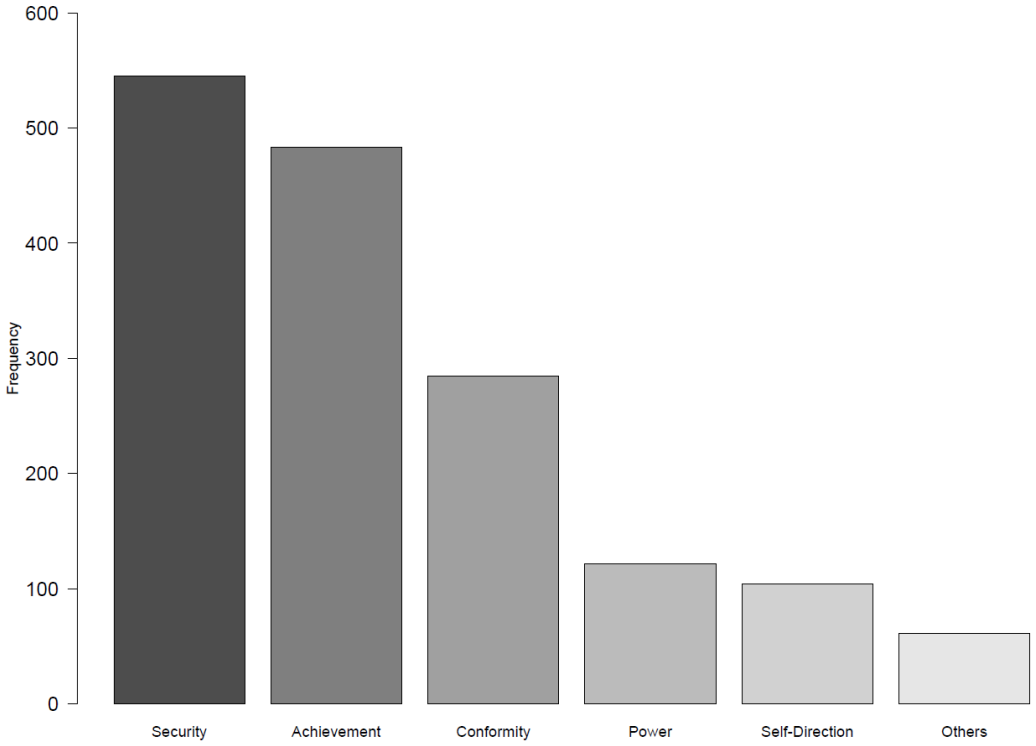

Figure 3 Frequency of code occurrence: types of values. "Others" includes benevolence, stimulation, universalism, and hedonism.

In the absence of institutionalized insurance mechanisms, respondents relied on keeping additional cattle (as explained by respondent 27 below) or stockpiling grains and pulses to store wealth. This strategy was seen as most reliable to quickly mobilize cash in times of urgent need.

"Maybe you, working with white people, people know you have money in the bank so people can give you credit. But here in the bush, if a Fulani tells you he has money in the bank, you know that he is lying to you." (Q27:22, Cluster IV, Loropéni, 31.08.2019)

Table 3 Value profiles of respondents by cluster (percentages of total code occurrence)

	Sedentary Lobi taurine (Cluster I)	Sedentary crossbreed (Cluster II)	Semi-Transhumant-Zebu (Cluster III)	Transhumant-Zebu (Cluster IV)
Security	32[a]	32[a]	36[a]	36[a]
Achievement	37[a]	33[ab]	25[bc]	24[c]
Conformity	13[a]	15[ab]	22[bc]	23[c]
Power	8[a]	9[a]	7[a]	6[a]
Self-Direction	6[a]	7[a]	6[a]	6[a]
Others	4[a]	3[a]	4[a]	5[a]

[abc] Numbers within rows that do not have a common superscript indicate a significant difference at $p < 0.05$ level

Achievement

Achievement, defined as a recurring, large harvest of diverse crops, was the most important value for crop-oriented respondents (clusters I and II). For semi-transhumant and transhumant respondents (clusters III and IV), the number and appearance of animals owned was considered the main characteristic of achievement and ranked second among all values for this group:

> *"A successful cattle keeper is one who has a lot of animals, he is the one we call a great producer, anyway. A successful farmer is one who cultivates to have many granaries and bags – they are what we call great farmers." (Q18:20, Cluster III, Kampti, 20.08.2019).*

There was a significant association between the type of cluster and the frequency of belief statements related to achievement (Table 3). The cattle-keepers felt competent to select the best animals (e.g. respondent 22 below) for breeding and manage their herds optimally given the landscape trends mentioned above.

> *"The breeding bull (...) is a bull in good shape, with a good body, his scrotum is well descended, when you see him even you agree. At a glance, you can know that this bull can be big and fit, through his growth."* (Q22:18, Cluster III, Kampti, 23.08.2019)

Conformity

Across all clusters, the respondents valued conformity and tradition highly (e.g. respondent 26 below). Belief statements in this category typically stated how "we" do things "here", and indicated social norms, particularly regarding acceptable behavior (working hard) to achieve wealth or power. There was a significant association between the type of cluster and the frequency of belief statements related to conformity (Table 3).

> *"My son cannot refuse to cultivate or keep cattle. I myself grew up and saw my parents doing it (laughter). He too has grown up and he has seen me doing it – if he refuses now, he is an idiot, it is his problem, he himself will suffer." (Q26:25, Cluster II, Loropéni, 02.09.2019)".*

The respondents also considered roles in their communities to be defined based on ethnicity or gender, e.g. Fulani being cattle keepers and herders, and women being responsible for milking and marketing dairy products:

> *"God created us with cattle. Even if a Fulani is poor, he will buy at least one cattle and tether it in front of his door to look at it every day." (Q28:40, Cluster IV, Loropéni, 01.09.2019)*

Power

Power (including social recognition, authority, and wealth) emerged as fourth most frequently stated value. For respondents, *achievement* translated into *power* when success became visible for others, thus contributing to social reputation, as explained by respondent 3:

> *"You also know that, nowadays, if you have nothing you cannot be in front of people. (...) Someone may come to the village from somewhere else, hear your name and then come, and sleep hungry. He wakes up hungry. If they put you in front of things, what can you do? You can't do anything, you can't develop the village." (Q3:31, Cluster I, Bouroum-Bouroum, 28.07.2019).*

Power and conformity were aligned when respondents stated that they did not necessarily wish others to succeed or share their successes with others, including animals:

"We don't want anyone to outdo someone else. (…). He doesn't want his good bull to go and mate with someone else's cattle so that he too has good cattle. This is a great difficulty even." (Q9:39, Cluster II, Bouroum-Bouroum, 27.07.2019)

Self-direction

Self-direction can be considered diametrically opposed to the more prevalent value of *conformity*. When respondents expressed beliefs indicating self-direction, they often referred to their children and education, like respondent 21:

"Well! Like the children, some of them are students, agriculture is not part of their activities. (…) If you force them nowadays, you cannot force the children. The spirit with which they grew up, you leave them with that spirit and do your work." (Q21:4, Cluster II, Kampti, 21.08.2019)

Many respondents considered employment in the public sector or commerce as being a better livelihood than agriculture. They saw education as a main pathway out of the hard livelihood of agriculture:

"Agriculture is a good occupation, but as people say, it will hurt your back. If you do well in school, you will get your job. You are a doctor, you are a Gendarme, you are a policeman, you earn your money by sitting only, to feed yourself, to do whatever you want. I like this." (Q14:6, Cluster I, Bouroum-Bouroum, 13.08.2019)

Correlation of values

To further investigate the respondents' value profiles in and their possible relation to different livelihood strategies, we explored the correlation of code-occurrences separately for cropping-oriented clusters (I and II) and livestock-oriented clusters (III and IV). The results (Tables 4 and 5) corroborate the interpretation that for respondents from cluster I and II, *achievement* and *power* are considered main pathways towards security. For respondents from clusters III and IV, however, the role of *conformity* in relation to *security* is more pronounced, whereas more individualistic values like *power* and *self-direction* show negative correlation tendencies in relation to *security*. In contrast to crop-oriented clusters, *power* was positively associated with *self-direction* for livestock-oriented respondents (significant at $p<0.05$).

Table 4 Clusters I and II: correlation between value-code occurrences

	Achievement	*Conformity*	*Power*	*Security*	*Self-Direction*
Achievement	1.000	-	-	-	-
Conformity	0.570*	1.000	-	-	-
Power	0.643**	0.436	1.000	-	-
Security	0.847**	0.583*	0.515*	1.000	-
Self-Direction	0.005	-0.089	-0.249	0.099	1.000

*, ** Correlation significant at the 0.05 and 0.01 levels, respectively

Table 5 Clusters III and IV: correlation between value-code occurrences

	Achievement	*Conformity*	*Power*	*Security*	*Self-Direction*
Achievement	1.000	-	-	-	-
Conformity	0.454	1.000	-	-	-
Power	-0.228	0.054	1.000	-	-
Security	0.624**	0.652**	-0.199	1.000	-
Self-Direction	-0.297	-0.100	0.458	-0.362	1.000

*, ** Correlation significant at the 0.05 and 0.01 levels, respectively

VII. Discussion

The purpose of this study was to understand the values and beliefs that shape choices by cattle keepers in south-western Burkina Faso. Based on our findings, we draw three main conclusions which should be taken into account if a change in breeding practices is to be fostered.

7.1. Integrate security concerns and make achievements visible

Across all clusters, the vulnerability of their livelihoods was the respondents' biggest concern, which corresponds to the strong value they assigned to *security*. Earlier research in the region backs the perceptions of the challenges to livestock production at the landscape (e.g. climate dynamics) and regime level (e.g. institutional framework) (Koutou et al. 2016; Zoma-Traoré et al. 2020). Also, several studies in the region have underlined the constant struggle to manage livelihood vulnerability (e.g. Ilatsia et al. 2012; Traoré et al. 2017)**.** However, smallholders were found to be rather skeptical of changing their practices, particularly when benefits are not as obvious or immediate (e.g. Wiggins 2016). Therefore, we suggest that for a community-based breeding program to be successful in the region, it should put the reduction of current livelihood risks at the center of its narrative and strategy. Participating in the CBBP and exploring new cattle breeding strategies should include opportunities to reduce or buffer losses, even beyond livestock keeping.

Secondly, we propose that the motivation to be judged as successful by others (*achievement)* will need to be integrated into the CBBP process. Considering the central role of *achievement* and *power* particularly for crop-oriented respondents, the potential and results of a change in cattle breeding practice should be made visible and framed as a pathway towards success and social recognition. In other regions, breeding stock from CBBPs yielded significantly higher prices (Haile et al. 2020). Also, the importance of being seen as a "good farmer" has been established earlier, as well as the challenge of not being able to see immediate benefits through livestock breeding (e.g. Burton 2012; Haile et al. 2019, 2020). We further suggest that long-term commitment and trust among stakeholders will be key to establish a partnership that will last to see the benefits of breeding efforts. The pivotal role of a lead stakeholder who is seen and accepted as being unbiased in such a partnership has been highlighted earlier (Probst et al. 2019; Ndah et al. 2020). Indeed, several studies showed that breeding programs can fail if the trust in leadership and organization is low (Camara et al. 2019; Wurzinger and Gutierrez 2017). In sum, a shared, transparent understanding of the potential and likely benefits of systematic breeding and how it can be organized should be at the heart of a CBBP.

7.2. Resonate with existing norms

Our results illustrate the commonly practiced strategies in cattle breeding in the region. These strategies have typical characteristics of a social norm: the respondents related their strategies to their peer group and the area, framed their choices as unavoidable and had clear concepts of (un)acceptable behaviors. Staying within these boundaries was important for respondents, and particularly so in livestock-oriented households who clearly associated *conformity* with *security*. The respondents also underlined their confidence in mastering livestock-breeding using conventional practices. We suggest that establishing a CBBP needs to carefully integrate

the established norms into a new narrative of livestock-breeding. Earlier research has shown that a change in practices is not only challenging at the individual level, but can be seen as a role deviation that is sanctioned by the community (Hauser et al. 2016). As a first step, breeding programs would thus have to understand relevant existing norms and practices, as argued by earlier studies (e.g. Kosgey et al. 2006). Respondents will be reluctant to change breeding strategies that are seen as the 'default', a bias that has been shown to be related to loss-aversion and the cognitive effort to learn and evaluate new options (e.g. Kahneman et al. 1991). Several studies have described cases of breeding programs not resonating sufficiently well with the participants' norms (e.g. Ilatsia et al. 2012; Leroy et al. 2015). We conclude that a CBBP may increase its appeal by building on existing collaborative practices (farm labour, hunting) and by sensitively developing a locally adapted version of systematic, community-based breeding as the new default.

7.3. Address organizational and technical challenges

While the focus of this study has been on values and beliefs shaping cattle breeding, our results also highlighted issues of organizational and technical nature. Group mating was the standard breeding strategy, as also shown in similar cases (e.g. Ejlertsen et al. 2013; Ilatsia et al. 2012). Systematic breeding efforts need to be adequately integrated with current practices of free-roaming and group mating, which may require adapted cattle management arrangements. The question of how such arrangements can be put into place are a key aspect of a CBBP. The possibilities to institutionalize breeding has been discussed for many years (e.g. Haile et al. 2014). To ensure the necessary buy-in of cattle-keepers, the institutional set-up would have to emerge from the interactions within the community. A promotor of CBBP could suggest different ideas to the community as a starting point for discussion: bull-sharing groups that agree on castrating all bulls except the selected breeding bulls, which could be rotated to other groups consecutively as agreed on by the community; common herding of cows in the community, joined only by selected mating bulls; a formal breeders association that works towards the common interest of all members; castration of inferior bulls individually by all cattle keepers. Finally, improving access to veterinary services, capacity building and measures to reduce livelihood risks, in general, may increase the livestock-keepers' willingness to engage in systematic breeding of cattle, including Lobi taurine.

VIII. Conclusion

Given the importance of cattle production for livelihoods in south-western Burkina Faso, and the need for novel approaches to cattle management and breeding, the main purpose of this study was to understand cattle keepers' values and beliefs. The respondents observed that their livelihoods were under increasing pressure by the scarcity of resources, the changing climate,

and cattle diseases. Current institutional arrangements and market opportunities only partly mitigate these pressures. The respondents react by diversifying their livelihood strategies but maintain established cattle and crop production approaches. The vulnerability of their livelihoods was the respondents' biggest concern, and the data established *security* as the respondents' dominant value, closely linked to *achievement* in terms of harvest and animal quantity. Particularly for livestock-oriented respondents, *conformity* with accepted social roles was valued, while *achievement* and *power* were more pronounced among crop-oriented respondents. We conclude that, in order to preserve local cattle breeds and innovate management and breeding practices, a CBBP will have to make the reduction of risk its core identity, and carefully integrate established norms in a new narrative of livestock keeping. A locally adapted institutionalization of systematic, community-based breeding could build on existing collaborative practices but would require novel cattle keeping and feeding arrangements. While localized scientific expertise may support the development of such arrangements, we consider trusted leadership emerging from the community as pivotal for a longer-term innovation process.

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Author declarations

Anonymized data that support the findings of this study are available on request from the corresponding author L.P. The data are not publicly available due to them containing information that could compromise respondent privacy. All research undertaken in the course of this study adhered to relevant EU and Austrian legislation including the EU General Data Protection Regulation (GDPR), as well as the ethical approval regulations of BOKU-University of Natural Resources and Life Sciences, Vienna. To secure the confidentiality, accuracy and security of the data, the following measures were taken: (1) only necessary data were collected (data minimization principle); (2) a pseudonymization strategy was applied; (3) data were available to the research team only after blinding (anonymization) by the team member collecting the data; (4) raw data are stored on secure servers; (5) at no point were identifiable personal data published.

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Author contributions

Conceptualization: B.Z.-T., L.P., M.W., J.S., S.O.-K., A.S., A.T.; Methodology: L.P., B.Z.-T.; Investigation: B.Z.-T.; Analysis: B.Z.-T., L.P., N.K., J.S., Writing – Original Draft: B.Z.-T., L.P., M.W.; Writing –Review & Editing: S.O.-K., A.S., D.O., B.Y., A.T., N.K., G.M., P.A.B., O.A.M., J.S., B.Z.-T., M.W., L.P.; Funding Acquisition: J.S., P.A.B, A.S.; Supervision: M.W., L.P., J.S.

References Paper II

Ajzen, I. 1991. The theory of planned behavior. Organizational Behavior And Human Decision Processes 50: 179-211. https://doi.org/10.1016/0749-5978(91)90020-T

Alvaredo, F., L. Chancel, T. Piketty, E. Saez and G. Zucman. 2018. World Inequality Report (2018) Cambridge: Belknap Press.

Bassi, E. M., E. Goddard and J. R. Parkins. 2019. "That's the Way We've Always Done It": A Social Practice Analysis of Farm Animal Welfare in Alberta. Journal of Agricultural and Environmental Ethics 32: 335-354. doi: 10.1007/s10806-019-09777-0

Borges, J. A. R., L. W. Tauer and A. G. J. M. Lansink. 2016. Using the theory of planned behavior to identify key beliefs underlying Brazilian cattle farmers' intention to use improved natural grassland: A MIMIC modelling approach. Land Use Policy 55: 193-203. doi: https://doi.org/10.1016/j.landusepol.2016.04.004

Burton, R. J. F. 2012. Understanding Farmers' Aesthetic Preference for Tidy Agricultural Landscapes: A Bourdieusian Perspective. Landscape Research 37: 51-71. doi: 10.1080/01426397.2011.559311

Camara, Y., N. Moula, F. Sow, M. M. Sissokho and N. Antoine-Moussiaux. 2019. Analysing innovations among cattle smallholders to evaluate the adequacy of breeding programs. Animal 13: 417-426. doi: 10.1017/S1751731118001544

Chambers, R., A. Pacey and L. A. Thrupp. 1989. Farmer first: farmer innovation and agricultural research. London: Technology Publications, pp.218.

Cherlet, M., C. Hutchinson, J. Reynolds, J. Hill, S. Sommer and G. Von Maltitz. 2018. World Atlas Of Desertification: Rethinking Land Degradation And Sustainable Land Management. Publications Office of the European Union. https://www.preventionweb.net/publications/view/58903#:~:text=World%20Atlas%20of%20Desertification%3A%20Rethinking%20land%20degradation%20and%20sustainable%20land%20management,-

Source(s)%3aText=This%20third%20edition%20of%20the,Global%20sPatterns%20of%20Human%20Domination.&text=Limits%20to%20Sustainability.

Darnhofer, I. 2020. Farming from a Process-Relational Perspective: Making Openings for Change Visible. Sociologia Ruralis 60: 505-528. doi: 10.1111/soru.12294

De Lauwere, C., M. Van Asseldonk, J. Van 't Riet, J. De Hoop and E. Ten Pierick. 2012. Understanding farmers' decisions with regard to animal welfare: The case of changing to group housing for pregnant sows. Livestock Science 143: 151-161. doi: https://doi.org/10.1016/j.livsci.2011.09.007

Ejlertsen, M., J. Poole and K. Marshall. 2013. Traditional breeding objectives and practices of goat, sheep and cattle smallholders in The Gambia and implications in relation to the design of breeding interventions. Tropical Animal Health And Production 45: 219-229. doi: 10.1007/s11250-012-0194-1

El Bilali, H., M. Hauser, S. Berjan, O. Miseckaite, & L. Probst. 2017. Rural livelihoods transitions: towards an integration of the sustainable livelihoods approach and the multi-level perspective. In Proceedings of the International Scientific conference on Rural Development, Aleksandras Stulginskis University Lithuania, November 23-2 2017.

Etana, D., C. F. A. Van Wesenbeeck and T. De Cock Buning (2020). Socio-cultural aspects of farmers' perception of the risk of climate change and variability in Central Ethiopia. Climate and Development: 1-13. doi: 10.1080/17565529.2020.1737796

FAO. 2013. In Vivo Conservation of Animal Genetic Resources. FAO Animal Production and Health Guidelines.No.14.; FAO: Rome, Italy, p.235. Available online: http://www.fao.org/3/i3327e/i3327e.pdf (accessed on 12 July 2019).

FAO. 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Rome, Italy: FAO Commission on Genetic Resources for Food and Agriculture Assessments. 12p. Available online: http://www.fao.org/3/i5077e/i5077e.pdf (Accessed on 7 March 2019).

Haile, A., T. Dessie and B. A. Rischkowsky. 2014. Performance of indigenous sheep breeds managed under community-based breeding programs in the highlands of Ethiopia: Preliminary results. Addis Ababa: ICARDA: hdl.handle.net/ 10568/35466

Haile, A., T. Getachew, T. Mirkena, G. Duguma, S. Gizaw, M. Wurzinger, J. Soelkner, O. Mwai, T. Dessie, A. Abebe, Z. Abate, T. Jembere, M. Rekik, R. N. B. Lobo, J. M. Mwacharo, Z. G. Terfa, G. T. Kassie, J. P. Mueller and B. Rischkowsky. 2020. Community-based sheep breeding programs generated substantial genetic gains and socioeconomic benefits. Animal: 14(7):1362-1370. doi: 10.1017/S1751731120000269

Haile, A., S. Gizaw, T. Getachew, J. P. Mueller, P. Amer, M. Rekik and B. Rischkowsky. 2019. Community-based breeding programmes are a viable solution for Ethiopian small ruminant genetic improvement but require public and private investments. Journal of Animal Breeding and Genetics 136: 319-328. doi: 10.1111/jbg.12401

Hansson, H. and K. Suvi. 2018. Farmers' mental models of change and implications for farm renewal – A case of restoration of a wetland in Sweden. Journal of Rural Studies 60: 141-151. doi: 10.1016/j.jrurstud.2018.04.006

Hauser, M., M. Lindtner, S. Prehsler, L. Probst. 2016. Farmer participatory research: Why extension workers should understand and facilitate farmers' role transitions. Journal of Rural Studies, 47, 52–61. doi: 10.1016/j.jrurstud.2016.07.007.

Ilatsia, E. D., R. Roessler, A. K. Kahi, H.-P. Piepho and V. Zárate. 2012. Production objectives and breeding goals of Sahiwal cattle keepers in Kenya and implications for a breeding programme. Tropical Animal Health and Production 44: 519-530. doi: 10.1007/s11250-011-9928-8

INSD. 2018. Annuaire statistique. Institut National de la Statistique et de la Demographie, Ministere de l´Economie et des Finances. Ouagadougou: Burkina Faso. Available online: http://www.insd.bf/n/contenu/pub_periodiques/annuaires_stat/Annuaires_stat_nationaux_BF/Annuaire_Statistique_National_2018.pdf (accessed on 15 2019).

IPCC. 2019. Climate Change and Land. Geneva: Intergovernmental Panel on Climate Change.

Jahel, C., X. Augusseau and D. Lo Seen. 2018. Modelling cropping plan strategies: What decision margin for farmers in Burkina Faso? Agricultural Systems 167: 17-33. doi: https://doi.org/10.1016/j.agsy.2018.08.004

Jarrett, F. G. 1985. Sources and models of agricultural innovation in developed and developing countries. Agricultural Administration 18: 217-234. doi: 10.1016/0309-586X(85)90092-5

Kahneman, D., J. L. Knetsch and R. H. Thaler. 1991. Anomalies: The Endowment Effect, Loss Aversion, and Status Quo Bias. Journal of Economic Perspectives 5: 193-206. doi: 10.1257/jep.5.1.193

Kassie, M., B. Shiferaw and G. Muricho. 2011. Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda. World Development 39: 1784-1795. doi: 10.1016/j.worlddev.2011.04.023

Klerkx, L., B. van Mierlo and C. Leeuwis. 2012. Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In Farming Systems Research into the 21st Century: The New Dynamic, eds. .: Springer, Dordrecht, Netherlands, pp. 457-483

Kosgey, I. S., R. L. Baker, H. M. J. Udo and J. A. M. Van Arendonk. 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Ruminant Research 61: 13-28. https://doi.org/10.1016/j.smallrumres.2005.01.003

Koutou, M., M. Sangaré, M. Havard, E. Vall, L. Sanogo, T. Thombiano and D. S. Vodouhe. 2016. Adaptation des pratiques d'élevage des producteurs de l'Ouest du Burkina Faso face aux contraintes foncières et sanitaires. Agronomie Africaine 28: 13-24.

Leroy, G., R. Baumung, P. Boettcher, B. Scherf and I. Hoffmann. 2015. Review: Sustainability of crossbreeding in developing countries; definitely not like crossing a meadow…. Animal 10: 262-273. doi: 10.1017/S175173111500213X

Martin-Collado, D., T. J. Byrne, C. Diaz and P. R. Amer. 2018. Complexity of animal breeding choice making. Journal of Animal Breeding and Genetics 135: 395-409. doi: 10.1111/jbg.12360

McIntyre, B. D., H. R. Herren, J. Wakhungu and R. T. Watson. 2009. Agriculture at a Crossroads. International Assessment of Agricultural Knowledge Science and Technology for Development (IAASTD): Global Report. Synthesis Report, Island Press, Washington DC, pp. 590.

Meijer, S. S., D. Catacutan, C. Oluyede, A. Gudeta, W. Sileshi and M. Nieuwenhuis. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability 13: 40-54. doi: 10.1080/14735903.2014.912493

Mopaté, L. Y., M. J. B. Kamuanga, S. Hamadou and C. Y. Kaboré-Zoungrana. 2014. Evaluation des pratiques paysannes de conservation in situ du taurin Baoulé au Sud-Ouest du Burkina Faso. Animal Genetic Resources 54: 171-178. doi: 10.1017/S2078633614000022

Mueller, J. P., B. Rischkowsky, A. Haile, J. Philipsson, O. Mwai, B. Besbes, A. Valle Zárate, M. Tibbo, T. Mirkena, G. Duguma, J. Sölkner and M. Wurzinger. 2015. Community-based livestock breeding programmes: essentials and examples. Journal of Animal Breeding and Genetics 132: 155-168. doi: 10.1111/jbg.12136

Ndah, H., L. Probst, S. Kaweesa, P. Kuria, S. Mkomwa, P. Rodrigues, G. Basch, G. Uckert, S. Sieber, A. Knierim, P. Zander and J. Schuler. 2020. Improving farmers' livelihoods through conservation agriculture: options for change promotion in Laikipia, Kenya. International Journal of Agricultural Sustainability 18: 212-231. doi: 10.1080/14735903.2020.1746063

Norman, D. W. 2002. The farming systems approach: A historical perspective. Presentation held at the 17th Symposium of the International Farming Systems Association in Lake Buena Vista, Florida, USA, 17-20 November 2002.

O'Kane, H., E. Ferguson, J. Kaler and L. Green. 2017. Associations between sheep farmer attitudes, beliefs, emotions and personality, and their barriers to uptake of best practice: The example of footrot. Preventive Veterinary Medicine 139: 123-133. doi: 10.1016/j.prevetmed.2016.05.009

Ouédraogo, D., A. Soudré, S. Ouédraogo-Koné, B. Zoma, B. Yougbaré, N. Khayatzadeh, P. Burger, G. Mészáros, A. Traoré, O. Mwai, M. Wurzinger and J. Sölkner. 2019. Breeding objectives and practices in three local cattle breed production systems in Burkina Faso with implication for the design of breeding programs. Livestock Science 232: 103910. doi: 10.1016/j.livsci.2019.103910

Pradhananga, A. K. and M. A. Davenport. 2019. Predicting Farmer Adoption of Water Conservation Practices Using a Norm-based Moral Obligation Model. Environmental Management 64: 483-496. doi: 10.1007/s00267-019-01186-3

Probst, L., H. T. Ndah, P. Rodrigues, G. Basch, K. Coulibaly and J. Schuler. 2019. From adoption potential to Transformative Learning around Conservation Agriculture. The Journal of Agricultural Education and Extension 25: 25-45. doi: 10.1080/1389224X.2018.1520733

Reij, C., G. Tappan, & M. Smale. 2009. Agroenvironmental transformation in the Sahel: Another kind of "Green Revolution". IFPRI Discussion Paper oo914. Washington DC: International Food policy Research Institute.

Röling, N. 2009. Pathways for impact: scientists' different perspectives on agricultural innovation. International Journal of Agricultural Sustainability 7: 83-94. doi: 10.3763/ijas.2009.0043

Schut, M., L. Klerkx, M. Sartas, D. Lamers, M. Mc Campbell, I. Ogbonna, P. Kaushik, K. Atta-Krah and C. Leeuwis. 2016. Innovation platforms: experiences with their institutional embedding in agricultural research for development. Experimental Agriculture 52: 537-561. doi: 10.1017/S001447971500023X

Schwartz, S. H. 1992. Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. In Advances in Experimental Social Psychology, ed. Mark P. Zanna, 1-65. New York: Academic Press. 6

Schwartz, S. H. 1994. Are There Universal Aspects in the Structure and Contents of Human Values? Journal of Social Issues 50: 19-45. doi: 10.1111/j.1540-4560.1994.tb01196.x

Stern, P. C., T. Dietz, T. Abel, G. A. Guagnano and L. Kalof. 1999. A value-belief-norm theory of support for social movements: The case of environmentalism. Human Ecology Review: 81-97.

Traoré, S. A., A. Markemann, C. Reiber, H. P. Piepho and A. Valle Zárate. 2017. Production objectives, trait and breed preferences of farmers keeping N'Dama, Fulani Zebu and crossbred cattle and implications for breeding programs. Animal 11: 687-695. doi: 10.1017/S1751731116002196

Wiggins, S., 2016. Risk aversion among smallholder farmers in Uganda. ODI: London.

Wrigley, M. 2001. Qualitative Research Interviewing: Biographic Narrative and Semi-Structured Methods. Forum: Qualitative Social Research, 3 (4), Art. 4, http://nbn-resolving.de/urn:nbn:de:0114- fqs020446.

Wurzinger, M. and G. Gutierrez. 2017. Analysis of a multi-stakeholder process during the start-up phase of two community-based llama breeding programs in Peru. Livestock Research for Rural Development 29, 1-8.

Zoma-Traoré, B., A. Soudré, S. Ouédraogo-Koné, N. Khayatzadeh, L. Probst, J. Sölkner, G. Mészáros, P. A. Burger, A. Traoré, M. Sanou, G. M. S. Ouédraogo, L. Traoré, D. Ouédraogo, B. Yougbaré and M. Wurzinger. 2020. From farmers to livestock keepers: a

typology of cattle production systems in south-western Burkina Faso. Tropical Animal Health And Production 52, 2179-2189. doi: 10.1007/s11250-020-02241

CHAPTER IV

Livestock Keepers' Attitudes: Keystone of Effective Community-Based Breeding Programs

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Abstract

Livestock keepers in southwestern Burkina Faso hold the local Lobi taurine breed, local Zebu cattle, and their crosses. Some communities in the region have begun to implement community-based cattle breeding programs (CBBPs), which involve animal tagging and recording and, potentially, also bull sharing. Based on the hypothesis that the participation of livestock keepers in CBBPs depends on their attitudes towards these programs, we used questionnaires to survey the attitudes of 125 farmers towards cattle breeding strategies and tools. Results were analyzed using principal component analysis. Farmers showed a highly positive attitude towards maintaining the features of their preferred cattle breed, but their attitudes varied substantially towards crossbreeding for breed improvement. Farmers generally agreed that performance was more important than animal appearance, and most of them were willing to cooperate with breeders' associations but were skeptical about sharing their bulls with other farmers. The majority was reluctant to record performance data, which may be due to a capacity deficit and their confidence in being able to select the best animals based purely on phenotype. Our analysis suggests that breeders' associations, as a key component of CBBPs, should lay down clear rules and obligations for their members from the outset. Timely consideration of farmers' attitudes towards different breeding tools may improve their uptake and guarantee the sustainability of CBBPs.

Keywords: breeding strategies; farmer attitudes; Burkina Faso

I. Introduction

Local breeds are particularly relevant in developing countries, where they contribute to farmers' livelihoods and have socio-cultural functions (FAO, 2015). These breeds have the advantage of adaptability to scarce and low-quality feed resources, adverse climatic conditions, and resistance to parasites and endemic diseases. However, their productivity is low (Dessie and Okeyo Mwai, 2019; FAO, 2015). In an effort to increase farm production, farmers are increasingly crossbreeding local breeds with more productive international breeds or even replacing the local breeds entirely (ILRI, 2008; Rege et al., 2011). This trend threatens the conservation and use of local breeds (FAO, 2007; Rege, 1999; Rewe et al., 2009).

In developing countries, genetic improvement of local breeds is one of the avenues to conserve them sustainably while supporting smallholder farmers (FAO, 2010, 2015). Conventional breeding programs can be quite difficult to implement in communities of smallholder farmers in developing countries (Mueller et al., 2015), which has led to the promotion of community-based breeding programs (CBBPs) (Haile et al., 2019; Mueller et al., 2015; Sölkner et al., 1998). CBBPs focus on indigenous stocks and strive to take into account the needs, views, decisions, and active participation of farmers (Haile et al., 2019; Haile et al., 2011; Mueller et al., 2015; Sölkner et al., 1998). Despite this goal, several CBBPs have failed because they did not adequately integrate the views of farmers, which resulted in low participation (Kosgey et al., 2006; Mueller et al., 2015). Thus, CBBP success depends on active participation by livestock

keepers as well as consideration of local knowledge and the institutional setting (Getachew et al., 2018; Kosgey and Okeyo, 2007; Wurzinger and Gutierrez, 2017; Wurzinger et al., 2011). The attitudes of livestock keepers towards the breeding strategy and tools proposed in CBBPs (or conventional breeding programs) can influence their willingness to participate (Martin-Collado et al., 2020). However, few studies have systematically examined these attitudes or how they may be linked to CBBP outcomes. Instead, the literature has focused more on technical aspects of program design and implementation (Abegaz et al., 2014; Gizaw et al., 2014; Mirkena et al., 2012) and their possible economic impact on farmers' livelihoods (Haile et al., 2020; Kaumbata et al., 2020).

In fact, farmers' knowledge, perception, and attitude towards a given technology help determine its success (Meijer et al., 2015). Farmers' attitudes are affected, in turn, by many personal factors (e.g., gender, age, marital status), socioeconomic factors (e.g., income, assets, education), and personality factors (e.g., self-confidence, readiness for innovation) as well as familiarity with the technology. Its adoption can also be determined by the agro–ecological environment, surrounding culture, political conditions, user-friendliness of the proposed technology, as well as the costs and benefits for farmers (Meijer et al., 2015).

Better understanding of the livestock keepers' attitudes towards different breeding tools will help design more effective CBBPs as well as improve farmer participation and support from extension services. Taking into account local attitudes is all the more important because of how much production, management, and socioeconomic factors can vary within and across geographic areas (Madalena et al., 2002; Robinson et al., 2011). In addition, farmers can vary in their attitudes towards breeding approaches and tools (Martin-Collado et al., 2020) as well as disease risk management, conservation, and animal welfare (Ahnström et al., 2009; Garforth et al., 2013; Kielland et al., 2010). This heterogeneity is particularly evident in developing countries, where farming remains less intensified and homogenized than in developed countries.

The present study assessed the attitudes of farmers in southwestern Burkina Faso towards breeding strategies and explored attitudinal differences among different farmer communities. The study also examined the implications of such attitudes for the design and implementation of CBBPs in the area.

II. Materials and Methods

2.1. Study Site

The research was conducted in the mountainous South-Sudanian ecological zone in southwestern Burkina Faso (Figure 1). The area is inhabited by approximately 850,000 people comprising the "local" ethnic groups Lobi, Dagara, Birifo, Djan, and Pogouli, as well as the "immigrant" groups Mossi, Fulani, and Bobo (INSD, 2018). Their primary economic activities are cattle and crop production (Ouédraogo et al., 2019). The breeds in this area include the two most common cattle breeds in Burkina Faso, namely the indigenous Lobi taurine (named after the Lobi ethnic group) and the Zebu, as well as crosses between these two breeds.

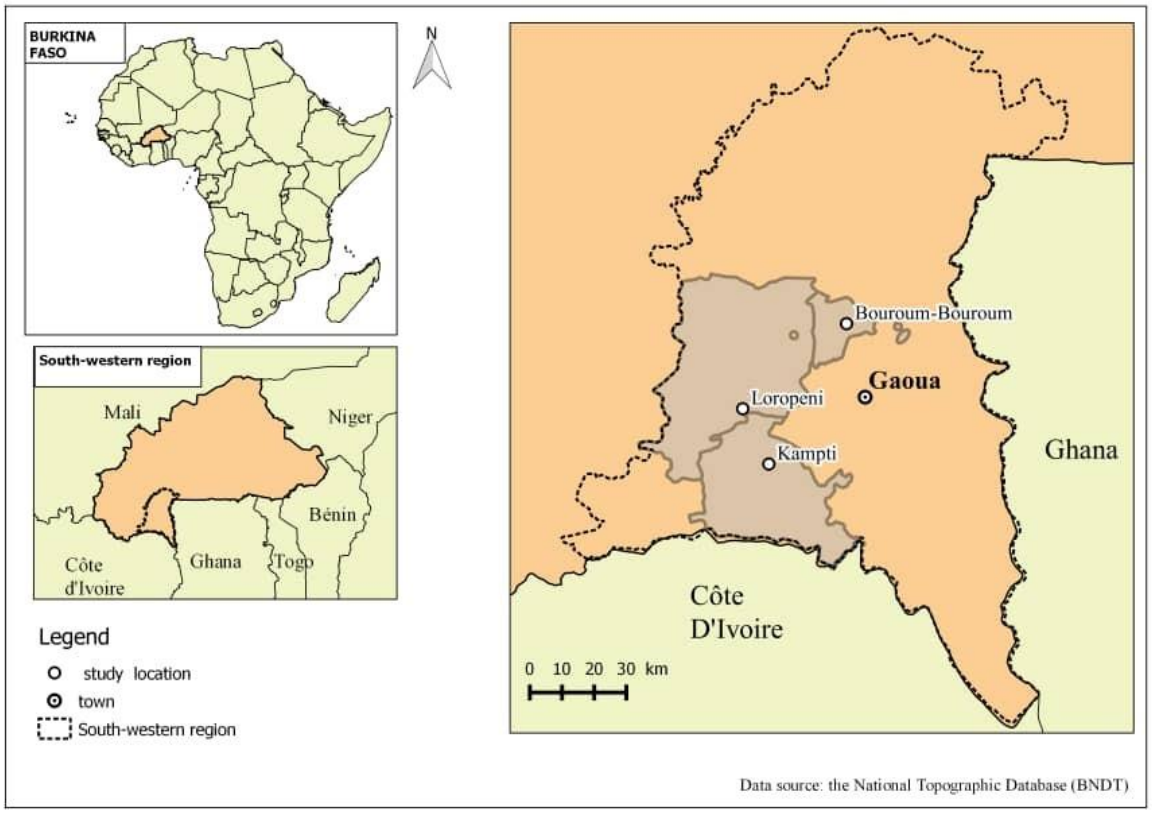

Fig.1 Location of the study sites

Rainfall patterns have recently become more erratic than in the past, and livestock production is constrained by parasite and disease pressures (Zoma-Traoré et al., 2020). To improve productivity, farmers have begun crossing the local Lobi taurine breed, reducing the pure local populations (Mopaté et al., 2014; Porter et al., 2016; Soudré et al., 2013). To help conserve and improve Lobi cattle, local authorities and livestock researchers have recommended CBBPs similar to those that have proven successful in other developing countries (Haile et al., 2019). Two universities and one research institute in Burkina Faso, in collaboration with two universities in Austria, have launched the project "Localbreed—Local Cattle Breed—Burkina Faso" to implement CBBPs aimed at conserving and improving pure Lobi cattle as well as Zebu x Lobi crossbreds (Locabreed, 2015-2020).

2.2. Sampling

In a 2018 study in the same area, we developed a typology of cattle production systems based on a sample of 169 households (Zoma-Traoré et al., 2020). Four cattle production systems were identified: (1) sedentary Lobi farms, (2) sedentary crossbreed farms, (3) semi-transhumant Fulani Zebu farms, and (4) transhumant Fulani Zebu farms. Our intention was to include these same households in the present study to investigate the attitudes of farmers toward breeding instruments. However, some households moved away after the previous study, so in the present work, we were only able to include 125 of the original 169 households.

2.3. Farmer Survey and Attitudinal Statements

We evaluated farmers' attitudes using a set of attitudinal statements towards which farmers stated their agreement using a six-level Likert scale: totally disagree, disagree, somewhat disagree, somewhat agree, agree, and totally agree. Such a scale avoids the central tendency bias. We also included the option: "I do not know/I do not have an opinion on this". The list of attitudinal statements was defined based on a study of sheep and beef farmer attitudes in Australia, New Zealand, and Spain (Martin-Collado et al., 2020). The statements were adapted to local conditions by taking into account local breeding practices and the current state of breeding programs. For example, statements related to the use of genomic information were removed, and two statements related to farmers' collaboration and bull sharing were added. The final list consisted of 10 statements, 8 of which were common to the attitudinal scale in the previous work (Martin-Collado et al., 2020) (Table 1). The list of statements that made up the core of a longer questionnaire also included questions about the farming system, farmer profile, farmer breeding strategies, and breeding tools.

Table 1. Attitudinal items on the survey.

Attitudinal Item	Variable
* It is very important to maintain the breed features of bulls/cows.	MaintainBreedFeatures
* Crossing animals of different breeds should be avoided when improving beef cattle performance.	AvoidCrossing
* The appearance of a bull/cow ("beauty of animals") is sufficient for telling its performance.	AppearanceIndicatePerform
* I do not need a person to come and record performance data on a bull/cow in order to know how good the animal is.	RecordingNotImportant
* The appearance of a bull/cow ("beauty of animals") is more important than its performance.	AppearanceMoreImpPerform
* The appearance of progeny ("beauty of animals") completely indicates how good the bull/cow is.	AppearanceProgenyImportant
*,# Artificial insemination does not help improve the performance of a cattle herd.	AI_NotHelpPerformance
+ Sharing or exchanging bulls between farmers is important for improving the performance of a cattle herd.	BullShareImportance
* In order to improve the performance of my herd, collaboration with other farmers to compare animals is crucial.	FarmerCollabCrucial
+ Being a member of a cattle breeders' association helps me to improve my herd.	BreederAssocHelps

2.4. Data Collection

We contacted the heads of household and carried out face-to-face interviews from July to September 2019. We used local materials, such as pebbles or shea nuts, to explain the 7-point scaling system for responding to survey items (Bellon, 2001), where 0 meant "I do not know/I do not have an opinion on this"; 1, totally disagree; 2, disagree; 3, somewhat disagree; 4, somewhat agree; 5, agree; and 6, totally agree. The respondents decided where and when to conduct the survey/interview session and in which language (Dioula, Mooré, or French). Before an interview, farmers were individually asked to consent to the recording of the sessions and for the results to be used for scientific work.

2.5. Data Analysis

2.5.1. Dataset Preparation

We first carried out quality control of the dataset. Households for which the interview contained more than three responses of "I do not know/I do not have an opinion on this" were removed, which was the case for one household. This response was given by 37–70% of respondents, depending on the production system, with reference to the statement on artificial insemination, so this statement was removed from the analysis. Therefore, we analyzed nine attitudinal statements in the end. Values were imputed for observation with three or fewer missing values ($n = 33$) not to miss the remaining statements' information. We used the expected maximization algorithm in the "Amelia" package of R (version 3.6.1) (Martin-Collado et al., 2020).

2.5.2. Statistical Analyses

Analysis of Responses about Production Systems

Among variables describing farmers' profile, farming system, and breeding management, the mean and the standard deviation were calculated for continuous variables, while the percentage was calculated for categorical variables. Before data analysis, we carried out the Shapiro test and Q-Q normality plots to examine the distribution of data. As data did not follow a normal distribution, we carried out nonparametric tests. Differences between production systems were assessed for significance using the $\chi 2$ test (categorical variables) or using the nonparametric Kruskal–Wallis test followed by Wilcoxon-test with Bonferroni–Holm correction (continuous variables). Differences were considered significant at $p < 0.05$.

Analysis of Responses to Attitudinal Statements

Principal component analysis (PCA) was used to investigate relationships among farmers' attitudes towards different breeding aspects and explore the variability of these attitudes across the entire farmer sample. In particular, we aimed to identify for which attitudinal statements there was concurrence of agreement or disagreement and those for which there was strong heterogeneity. PCA was carried out using the FactoMinerR package, and results were plotted using the FactoExtra package, both in R (version 3.6.1). Principal components (PCs) with an eigenvalue of at least one were retained (Kaiser's criterion) (Bidogeza et al., 2009; Kuivanen et al., 2016). We analyzed variation in farmers' attitudes across the four production systems, which were plotted around the mean values for each farming system, and then confidence

ellipses were drawn on the PCA plots. Finally, to help interpret the PCA results, we calculated the average agreement for each original attitudinal statement in each production systems

The lengths of the vectors (i.e., arrows) indicate how strongly the associated variable influences the PC. Therefore, they are directly proportional to the variation of that variable in the sample. For example, a very short arrow indicates that the two PCs contain nearly no information about the variable in question. The angle between any two arrows represents the correlation between the associated variables. When the angle between two variable vectors is 90 degrees, the two variables are deemed to be orthogonal and uncorrelated. Smaller angles indicate positive correlation; larger angles, negative correlation. Finally, the location of the dots (i.e., observations) in the plot is related to the score for each variable according to the direction of the arrows.

III. Results

The main characteristics of the four production systems (Table 2) were consistent with those of the 2018 study conducted in the same area (Zoma-Traoré et al., 2020). For all production systems, farmers had an average age of 50 years, and most had no formal education. They had all inherited their farms and were working full-time as farmers. Most farmers relied on hired herders; in contrast, farmers who kept Lobi taurine cattle in sedentary systems were more likely to rely on family labour. All farmers had more than one breeding bull, and they preferred those breeding bulls to ones from outside their herd.

Table 2. Main characteristics of the four production systems.

Variable	Production System			
	I Sedentary taurine *n* = 61	II LobiSedentary crossbreed *n* = 19	III Semi-transhumant Fulani Zebu *n* = 33	IV Transhumant Fulani Zebu *n* = 11
Household attributes				
Age of household head, yrs (mean ± SD)	55.5 ± 11.1 [a]	55.1 ± 12.7 [a]	48.6 ± 12.8 [b]	52.6 ± 8.9 [a]
Education of household head (%)				
None	95.1 [a]	73.7 [b]	97.0 [ab]	90.9 [ab]
Basic	3.3 [a]	15.8 [a]	3.0 [a]	0.0 [a]
Secondary	1.6 [a]	10.5 [a]	0.0 [a]	9.1 [a]
Technical training	0.0	0.0	0.0	0.0
Time spent on the farm (%)				
Full-time	100 [a]	100 [a]	100 [a]	100 [a]
Part-time	0	0	0	0
Use of hired labour (%)				
Yes	21.3 [a]	63.2 [b]	51.5 [b]	81.8 [b]
No	78.7 [a]	36.8 [b]	48.5 [b]	18.2 [b]
Farm inherited by household head (%)				
Yes	100 [a]	100 [a]	100 [a]	100 [a]
No	0	0	0	0
Livestock ownership and management				
No. of animals (mean ± SD)				
Lobi breed				
Cows	9.2 ± 6.0 [a]	4.5 ± 3.8 [b]	0.9 ± 3.0 [c]	0.0 ± 0.0 [c]
Bulls	3.1 ± 2.1 [a]	1.3 ± 1.5 [b]	0.1 ± 0.4 [c]	0.4 ± 1.2 [c]
Crossbreeds				
Cows	0.7 ± 2.0 [a]	14.9 ± 13.5 [b]	11.6 ± 14.2 [b]	11.6 ± 16.2 [b]
Bulls	0.5 ± 0.9 [a]	2.7 ± 2.7 [b]	1.5 ± 1.4 [b]	3.2 ± 4.5 [b]
Zebu breed				
Cows	1.5 ± 3.9 [a]	5.5 ± 11.6 [b]	32.2 ± 30.1 [c]	106.0 ± 57.6 [d]
Bulls	1.6 ± 2.3 [a]	1.3 ± 1.1 [a]	3.3 ± 2.6 [b]	6.6 ± 3.8 [c]
Origin of bulls (%)				
(a) Directly from breeders or other farmers	42.6 [a]	36.8 [a]	6.1 [b]	18.2 [ab]
(b) Livestock sale/markets	1.6 [a]	0.0 [a]	3.0 [a]	9.1 [a]
Both (a) and (b)	1.7 [a]	5.3 [a]	0.0 [a]	0.0 [a]
From own herd	54.1 [a]	57.9 [a]	90.9 [b]	72.7 [ab]

PCA identified six PCs with eigenvalues of at least one that together described 90.0% of the total variance (Table 3). The first component explained 25.4% of the variance (Figure 2), and the four primary and positively correlated items were attitudes towards crossbreeding, collaboration between farmers, membership in a breeders' association, and bull sharing. This first PC correlated negatively with performance recording.

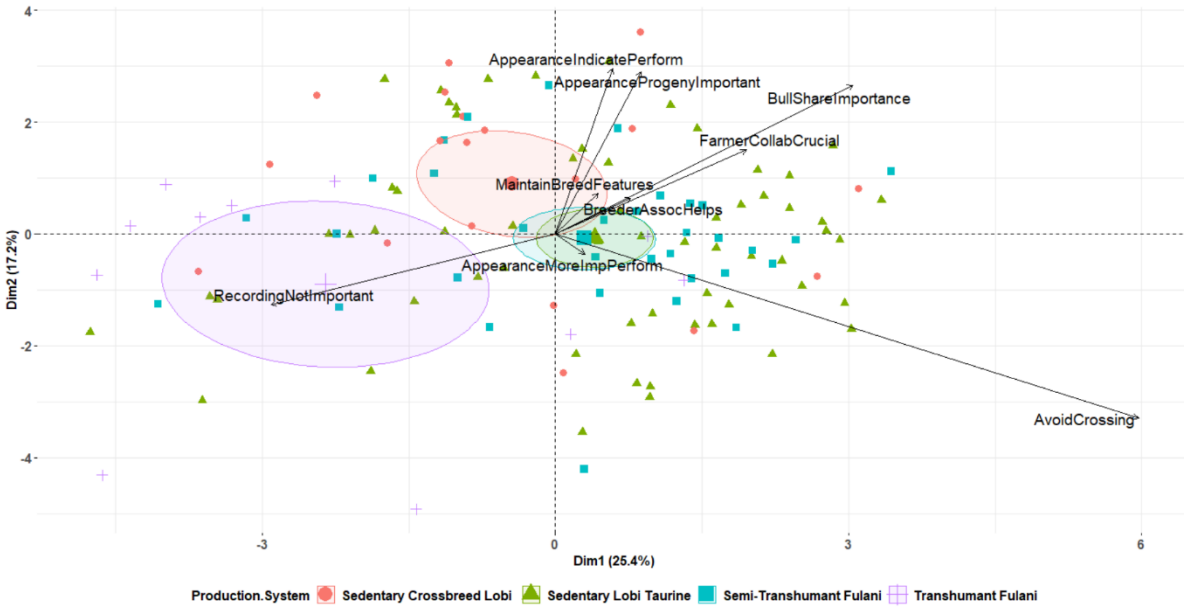

Figure 2. Principal component analysis (PCA) plot of farmers´attitudes in different production systems towards the variables of PC1 and PC2.

Table 3. Correlation of initial variables with principal components.

Variable	Principal Component					
	1	2	3	4	5	6
MaintainBreedFeatures	0.2	0.3 **	0.1	−0.2	−0.1	−0.1
AvoidCrossing	0.8 ***	−0.5 ***	0.3 **	0.1	0.1	0.1
AppearanceIndicatePerform	0.1	0.5 ***	0.7 ***	0.4 ***	0.1	−0.2 **
RecordingNotImportant	−0.5 ***	−0.2 *	0.4 ***	−0.1	0.7 ***	−0.1
AppearanceMoreImpPerform	0.1	−0.1	−0.4 ***	0.9 ***	0.2	0.1
AppearanceProgenyImportant	0.2 *	0.6 ***	0.2	−0.1	0.2	0.7 ***
FarmersCollabCrucial	0.4 ***	0.3 ***	−0.1	−0.3 ***	0.3 **	−0.5 ***
BreederAssocHelps	0.3 **	0.2 **	−0.1	−0.2 *	−0.1	0.2 *
BullShareImportance	0.6 ***	0.5 ***	−0.4 ***	−0.1	0.4 ***	−0.2
Eigenvalue	3.9	2.7	2.4	2.1	1.6	1.4
Percentage of variance explained	25.4	17.2	15.1	13.6	9.9	8.8
Cumulative variance explained		42.6	57.7	71.3	81.2	90.0

*, **, *** indicate significance at $p < 0.05$, $p < 0.01$, or $p < 0.001$, respectively.

The second component accounted for 17.2% of the variance and was explained by the following five variables: importance of the appearance of the progeny, animal appearance as a performance indicator, the importance of bull sharing, avoiding crossing, and collaboration among farmers. The biplot of PC1 and PC2 suggested a clear attitudinal difference between respondents from the "Sedentary Crossbreed Lobi" or "Transhumant Fulani" production systems. In the plot, the ellipse representing "Sedentary Crossbreed Lobi" lay opposite the variable "AvoidCrossing", indicating a positive attitude towards crossbreeding (Figure 2 and Figure 4). "Transhumant Fulani" respondents showed an attitude towards bull sharing opposite to that of all the other groups and were critical of farmers' collaboration as a tool to improve breed features.

Among attitudes that correlated strongly with PC 1 and 2, clear differences were not observed between respondents from "Sedentary Lobi Taurine" or "Semi-Transhumant Fulani" production systems (Figure 2). The confidence ellipses of these two systems lay in the center of the PC plot and covered the entire PC space, indicating high heterogeneity of attitudes. Attitudes varied the most among "Transhumant Fulani" farmers, reflected in the greater spread of the confidence ellipse.

The biplot of PC3 and PC4 revealed that “Sedentary Lobi Taurine” farmers had a strongly positive attitude towards bull sharing, while “Semi-Transhumant Fulani” farmers had a strongly positive attitude towards animal appearance as a good performance indicator (Figure 3). This biplot revealed substantial heterogeneity within both production systems.

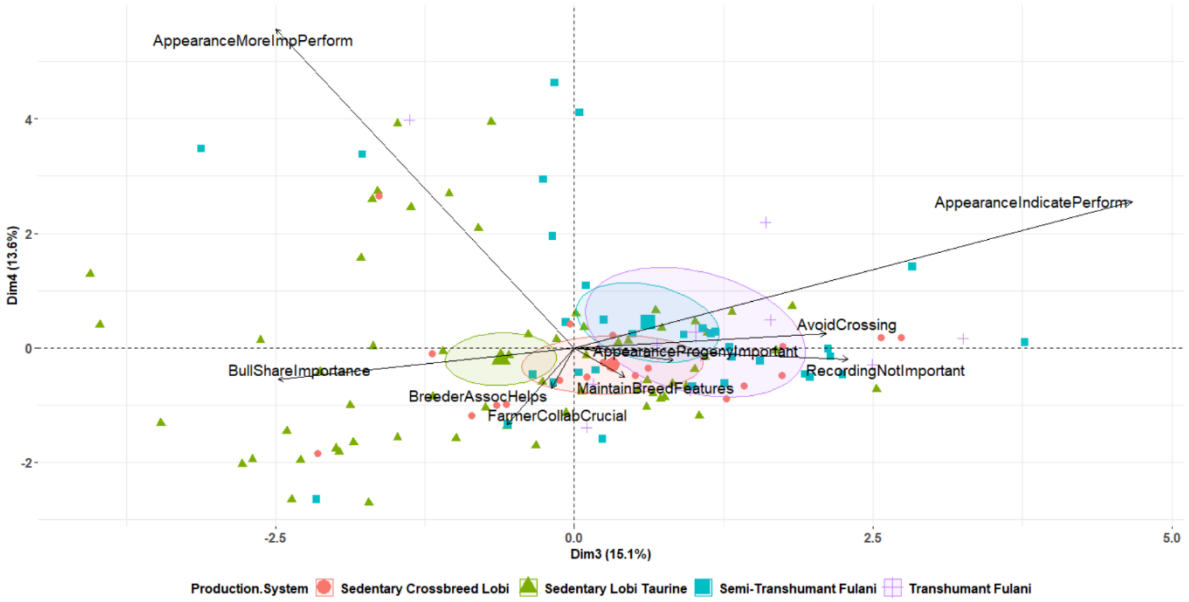

Figure 3. PCA plot of farmers’ attitudes in different production systems towards the variables of PC3 and PC4.

Farmers from all four production systems strongly supported maintaining breed features, relying on appearance as a performance indicator, being a member of a breeder’s association, and valuing animal performance more than appearance (Figure 4). “Transhumant Fulani” farmers were more critical towards performance recording, collaboration with other farmers, and sharing their bulls to improve herd performance.

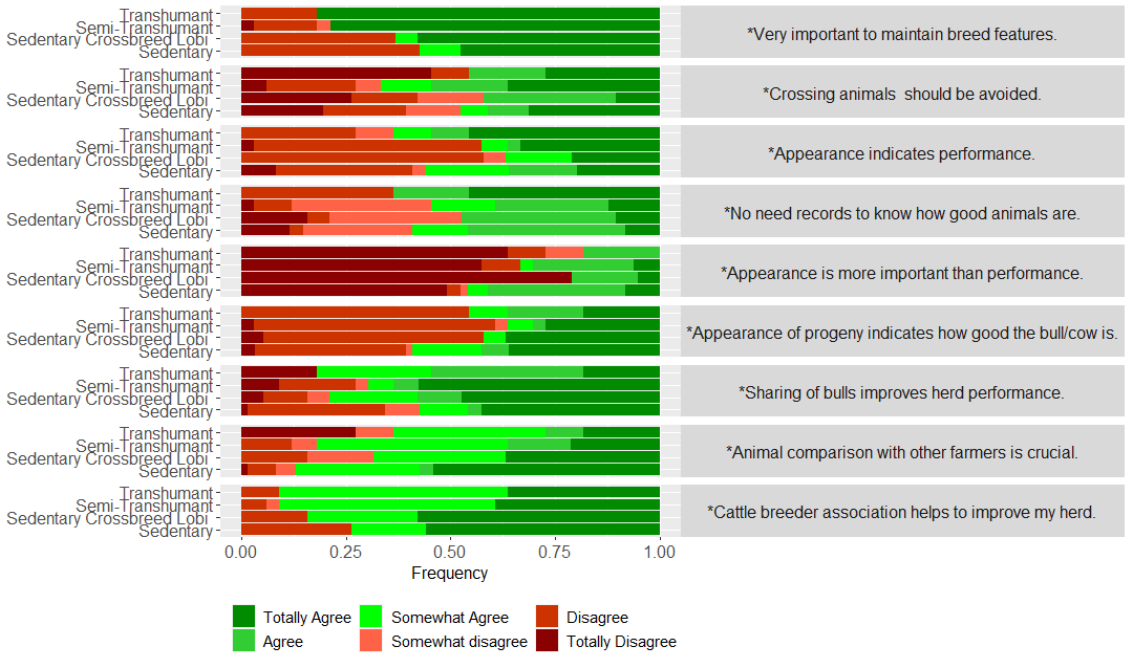

Figure 4. Farmers' attitudes of four production systems towards breeding tools.

Legend for Figure 4. Transhumant: Transhumant Fulani. Semi-Transhumant: Semi-Transhumant Fulani. Sedentary Crossbreed Lobi: Sedentary Crossbreed Lobi. Sedentary: Sedentary Lobi Taurine. * The full sentences can be found in the same order in **Table 1.**

IV. Discussion

This study investigated farmers' attitudes towards aspects of breeding relevant to the successful implementation of CBBPs. We focused on how attitudes varied within and across four production systems related to two ethnic groups (Lobi and Fulani), two livestock breeds (Taurine and Zebu), and three farming styles (Sedentary, Semi-Transhumant, and Transhumant), which we established in previous work (Zoma-Traoré et al., 2020). Our analysis identified three issues about CBBPs that may need to be addressed during their design and implementation: whether to prioritize pure breeding or crossbreeding, how to promote cooperation and bull sharing among farmers, and how to promote performance recording and animal tagging. Each of these issues is explored in greater detail below. Ensuring that these issues are resolved in alignment with the attitudes of participating farmers may help ensure that CBBPs are successful and sustainable.

4.1. Prioritizing Pure Breeding or Crossbreeding and "Beauty" or Performance

Across all four production systems, farmers showed a highly positive attitude towards maintaining the features of their preferred cattle breed. Lobi Taurine and Fulani Zebu are traditionally kept by different ethnic groups and play essential roles in their cultural practices, contributing to their respective cultural identities (Boutrais, 2007; De Rouville, 1987; Mopaté et al., 2014). This attachment of farmers to a particular breed will likely help conservation and breeding efforts as farmers should be more inclined to participate in breeding programs that are aimed at improving what they value, instead of switching cattle breeds as a response to changes in production systems, environmental factors, or market forces. In Uganda, the Ankole Cow Conservation Association has used this strategy of linking farmer identity to a breeding program to conserve Ankole cattle (Dessie and Okeyo Mwai, 2019). However, connections between ethnic groups and cattle breeds can change over time (Zoma-Traoré et al., Under review).

In our study, farmers from all production systems overwhelmingly supported the need to maintain breed features, yet they kept both pure and crossbred animals, especially the "Sedentary Crossbreed" farmers. Their visual appraisal of animals as pure or crossbred may not always be accurate. For example, Lobi animals that have been mixed with Zebu based on genomic analysis are frequently misclassified as pure by farmers (Ouédraogo et al., 2021). Indeed, many farmers in developing countries consider crossbreeding an attractive option for increasing their income (FAO, 2010; Galukande et al., 2013; Leroy et al., 2015; Roschinsky et al., 2015; Traoré et al., 2017). "Sedentary Crossbreed" farmers in our study area consider crossbreeding two local breeds to be a way to improve herd productivity (Zoma-Traoré et al., 2020).

However, researchers and international agencies have warned that farmers' interest in crossbreeding can lead to the loss of purebred cattle in Burkina Faso (Mopaté et al., 2014; Soudré et al., 2013) and elsewhere (FAO, 2015; Leroy et al., 2015). Our study shows that although farmers are clearly interested in crossbred animals, most of them are also concerned about retaining pure breed features. Nevertheless, CBBPs usually do not implement or promote well-designed crossbreeding strategies that minimize the risk of losing purebred cattle. This means that farmers are often left on their own when selecting bulls or making other breeding decisions, especially deciding which bulls to mate with crossbred females. We argue that both pure breeding and crossbreeding can and should be practiced in the same area and that farmers are aware of the benefits and risks of both approaches. Effective and sustainable parallel implementation requires institutionalization and possibly guidance from technical staff.

As part of the issue over pure breeding or crossbreeding, the farmers in our study generally agreed that animals' performance is more important than their appearance, which is in line with the study of Ankole cattle farmers in Uganda (Wurzinger et al., 2006). In many developing countries, farmers consider the well-being indicator "animal body condition score" as more important than any other attribute (Mutenje et al., 2020). A possible explanation is that cattle income makes an essential contribution to the household livelihood and that farmers prefer

animals that quickly reach market weight, while buyers prefer animals with good body condition. Indeed, animal body condition strongly influences farm gate price in Benin, Kenya, and Ethiopia (Fadiga, 2013; Kassie et al., 2011; Kinkpé et al., 2019; Mavedzenge et al., 2006; Ouma et al., 2007; Ruto et al., 2008), and good body condition is a prerequisite for adequate traction power for plowing. These considerations help explain why most breeding programs in developing countries aim to improve performance (Cloete, 2013). Consensus-building between farmers, researchers, and extension services may help make breeding goals more aligned with farmer attitudes and, therefore, more likely to succeed.

4.2. Promoting Cooperation among Farmers

Our study showed that farmers agreed with the importance of breeders' associations and inter-farmer collaboration to allow them, for example, to benchmark their herds against others. On the other hand, farmers did not always show positive attitudes towards bull sharing. While farmers appear to perceive the potential benefits of joining breeders' associations, such as greater income (Laborde et al., 2020) or greater sustainability of breeding programs (Gutu et al., 2015; Wollny, 2003)

Gutu et al. (2015) and Wollny (2003), they seem less willing to accept the implications of such participation, which includes bull sharing. In one study, farmers in Burkina Faso who were members of an association or cooperation showed a more positive attitude towards the conservation of Lobi cattle than farmers who were not members (Mopaté et al., 2014).

Based on our findings and the literature, we recommend the establishment of formally registered and recognized breeders' associations for Lobi cattle. These organizations should build on existing social structures to increase acceptance among farmers (Wurzinger et al., 2011). Membership should entail clear rules, rights, and obligations for each member (Wollny, 2003). During member discussions, the benefits of bull sharing to the participating farmers and the wider community can be emphasized to counteract the negative attitudes.

Considering the diverse attitudes towards bull sharing and farmer collaboration that we observed in our sample, particularly among "Transhumant Fulani" farmers, we recommend continuous dialog among stakeholders to jointly explore options for preserving and improving cattle breeds. A successful community-based breeding intervention needs to build on the commitment of livestock keepers, and the choice of certain farmers to opt-out must be respected.

4.3. Promoting Data Recording and Animal Tagging

Lack of performance data in smallholder farms is repeatedly cited as a major obstacle for breeding program success (Getachew et al., 2018; Mwacharo and Drucker, 2005). Farmers in our study seemed confident that the appearance of animals or that of their progeny are good

performance indicators, which implies that they do not see the need to record animal performance. Indeed, farmers may derive a sense of achievement from being able to select the best animals for breeding based only on their external features (Zoma-Traoré et al., Under review). Our results reflect the dominance of traditional farming practices in the study area, where the head of household generally exercises absolute power over cattle management (Mopaté et al., 2014; Ouédraogo et al., 2019; Zoma-Traoré et al., 2020). In addition, all the farmers in our study inherited their farms from their parents, and most of them place value on conforming to their parents' practices (Zoma-Traoré et al., Under review). Our analysis leads us to recommend demonstrating to farmers how performance and pedigree data can be used to preserve and improve the external traits they are familiar with, such as breed purity and bull performance.

Encouraging the recording of performance data will require overcoming several obstacles. These include lack of formal education and technical training among farmers, their advanced age, and their lack of workers with the time to routinely and accurately collect animal performance and pedigree data. For example, farmers from the "Sedentary Lobi Taurine" production system rely mostly on family members, who are often overwhelmed with other farm and domestic activities. Another obstacle is the lack of relevant skills and user-friendly infrastructure in information and communications technology, including robust and interactive databases.

Performance recording requires systematic tagging of animals (Haile et al., 2011; Oldenbroek and van der Waaij, 2014), yet many farmers in Ethiopia are reluctant to tag their animals because they believe it may cause infection and even death (Gutu et al., 2015). We suggest that CBBPs implement animal tagging and identification in a way that creates transparency and trust among stakeholders. One possibility is to implement a data-management responsibility chain (Haile et al., 2019) in which someone (e.g., an agricultural advisor) records data on the farm while external services analyze the data, the results of which are used to rank the animals.

If "outsiders", such as extension services, record and manage performance data, they should regularly provide feedback to farmers about the data to ensure trust and transparency and thereby improve farmer participation. This feedback is especially essential at the beginning of a breeding program so that farmers can familiarize themselves with data interpretation and grow in self-confidence. Indeed, continuous exchange with farmers is a critical element of CBBP viability (Haile et al., 2020; Mwacharo and Drucker, 2005; Wurzinger and Gutierrez, 2017). Allowing farmers to participate actively in the improvement and fine-tuning of breeding programs can increase their sense of ownership and turn program tools into "public goods" (Mrode, 2016).

Our present findings showing heterogeneity of livestock keepers' attitudes within and across different production systems echo results from our previous study in the same area (Zoma-Traoré et al., 2020). These findings suggest that the traditional view of the Fulani ethnic group as pure cattle keepers and the Lobi ethnic group as crop farmers who are less interested in cattle (Mopaté et al., 2014) is no longer valid. Both groups seem to have diversified their interests. In addition, the present study demonstrates how quantitative survey methods to investigate attitudes of respondents in rural communities can yield valuable data in contrast to what some

have suggested (Abebe et al., 2020; Duguma et al., 2011; Hamadou et al., 2019; Siddo et al., 2015). Careful adaptation of the research instruments to local conditions is essential (Porter et al., 2016).

V. Conclusions

This investigation of livestock keepers' attitudes towards breeding strategies and tools in Burkina Faso showed that farmers' attitudes towards crossbreeding of two local cattle types varied greatly, but they agreed that cattle performance was more important than their appearance. Farmers agreed on the importance of belonging to an association and collaborating with other members but did not necessarily agree on bull sharing. They were reluctant to record data on animal performance, which may reflect a lack of capacity and their own confidence in selecting breeding bulls. Our work shows the potential of attitudinal studies for informing the design and implementation of CBBPs. Conversations on attitudes provide a detailed picture of participating farmers' values and challenges, thus enabling stakeholders to collaborate more fruitfully. Expanding these conversations about attitudes to other stakeholders, such as extension services and research institutions, may be particularly beneficial. To be successful and sustainable, CBBPs should clearly define the obligations and roles of participating farmers, and they should provide systems for animal identification and performance recording to build trust and encourage stakeholders to continue systematic breeding activities.

Author Contributions

Conceptualization: D.M.-C., B.Z.-T., M.W., L.P., J.S., S.O.-K., A.S., A.T. and D.O. Methodology: D.M.-C., B.Z.-T. and M.W. Software: D.M.-C. Validation: D.M.-C., J.S. and G.M. Formal analysis: B.Z.-T. Investigation: B.Z.-T. Resources: J.S., A.S. and M.W. Data curation: D.M.-C. and G.M. Writing—original draft preparation: B.Z.-T. and M.W. Writing—review and editing: D.M.-C., L.P., S.O.-K., A.S., D.O., B.Y., A.T., N.K., G.M., P.A.B., O.A.M., J.S., B.Z.-T. and M.W. Visualization: B.Z.-T., D.M.-C. and G.M. Supervision: M.W., L.P. and J.S. Project administration: J.S. and A.S. Funding acquisition: J.S., P.A.B. and A.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy policy. Personal data from interview partners is not shared on a public space.

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Conflicts of Interest

All the authors declare no conflict of interest.

References Paper III

Abebe, A. S., K. Alemayehu, A. M. Johansson and S. Gizaw 2020. Breeding practices and trait preferences of smallholder farmers for indigenous sheep in the northwest highlands of Ethiopia: Inputs to design a breeding program. PLoS One 15: e0233040. doi: 10.1371/journal.pone.0233040

Abegaz, S., J. Sölkner, S. Gizaw, T. Dessie, A. Haile, T. Mirkena, T. Getachew and M. Wurzinger. 2014. Optimizing alternative schemes of community-based breeding programs for two Ethiopian goat breeds. Acta Agraria Kaposváriensis 18 (Suppl. S1), 47-55.

Ahnström, Johan, Jenny Höckert, Hanna L. Bergeå, Charles A. Francis, Peter Skelton and Lars Hallgren 2009. Farmers and nature conservation: What is known about attitudes, context factors and actions affecting conservation? Renewable Agriculture and Food Systems 24: 38-47. doi: 10.1017/S1742170508002391

Bellon, Mauricio R. 2001. Participatory research methods for technology evaluation: A manual for scientists working with farmers: CIMMYT: Mexico City, Mexico.

Bidogeza, J. C., P. B. M. Berentsen, J. De Graaff and A. G. J. M. Oude Lansink 2009. A typology of farm households for the Umutara Province in Rwanda. Food Security 1: 321-335. doi: 10.1007/s12571-009-0029-8

Boutrais, Jean 2007. The Fulani and Cattle Breeds: Crossbreeding and Heritage Strategies. Africa 77: 18-36. doi: 10.3366/afr.2007.77.1.18

Cloete, S. W. P. 2013. Breedingbreeding/breed, see also animal breedingin Developing Countriesbreeding/breed, see also animal breedingin developing countriesand Tropicsbreeding/breed, see also animal breedingtropics. In Sustainable Food Production, eds. Paul Christou, Roxana Savin, Barry A. Costa-Pierce, Ignacy Misztal and C. Bruce A. Whitelaw, 346-400. New York, NY: Springer New York.

De Rouville, C. 1987. Organisation sociale des Lobi: une societe bilineaire du Burkina Faso et de Cote d'Ivoire: L'Harmattan, Paris, France, 1987; p. 259.

Dessie, Tadelle and Ally Okeyo Mwai 2019. The story of cattle in Africa: Why diversity matters; ILRI, Rural Development Administration, Republic of Korea and AU-IBAR, Bureau for Animal Resources: Nairobi, Kenya, 2019; Available online: https://hdl.handle.net/10568/108945 (accessed on 7 September 2020).

Duguma, G., T. Mirkena, A. Haile, A. M. Okeyo, M. Tibbo, B. Rischkowsky, J. Sölkner and M. Wurzinger 2011. Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: choice model approach. Animal 5: 1984-1992. doi: 10.1017/s1751731111001029

Fadiga, Mohamadou L. 2013. Valuation of cattle attributes in the Malian humid and sub-humid zones and implications for the sustainable management of endemic ruminant livestock. Environmental Economics: 39-50.

FAO. 2010. Breeding Strategies for Sustainable Management of Animal Genetic Resources; FAO Animal Production and Health Guidelines. No 3.; FAO: Rome, Italy, p. 132. Available online: http://www.fao.org/3/i1103e/i1103e.pdf (accessed on 7 September 2020).

FAO 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Rome, Italy: FAO Commission on Genetic Resources for Food and Agriculture Assessments. 12p. Available online: http://www.fao.org/3/i5077e/i5077e.pdf (Accessed on 7 March 2019).

FAO 2007. The state of the world's animal genetic resources for food and agriculture – in brief, edited by Dafydd Pilling & Barbara Rischkowsky. Rome, Italy: Food & Agriculture Org. Available online: http://www.fao.org/3/a1260e/a1260e.pdf (Accessed on 14 May 2019).

Galukande, E, H. Mulindwa, M. Wurzinger, R. Roschinsky, A.O. Mwai, and J. Sölkner. 2013. Crossbreeding cattle for milk production in the tropics: achievements, challenges and opportunities. Animal Genetic Resources 52, 111–125.

Garforth, C. J., A. P. Bailey and R. B. Tranter 2013. Farmers' attitudes to disease risk management in England: A comparative analysis of sheep and pig farmers. Preventive Veterinary Medicine 110: 456-466. doi: https://doi.org/10.1016/j.prevetmed.2013.02.018

Getachew, Tesfaye, A. Haile and B. Rischkowsky 2018. How to tailor community based breeding programs for small ruminants to pastoral production systems. In Proceedings of the World Congress on Genetics Applied to Livestock Productions, Auckland, New Zealand, 11–16 February 2018; Volume 11, p. 858.

Gizaw, S., J. A. M. van Arendonk, A. Valle-Zárate, A. Haile, B. Rischkowsky, T. Dessie and A. O. Mwai 2014. Breeding programmes for smallholder sheep farming systems: II. Optimization of cooperative village breeding schemes. Journal of Animal Breeding and Genetics 131: 350-357. doi: https://doi.org/10.1111/jbg.12102

Gutu, Z., A. Haile, B. A. Rischkowsky, A. A. Mulema, W. Kinati and G. Tesfahun 2015. Evaluation of community-based sheep breeding programs in Ethiopia. Addis Abab: ICARDA. hdl.handle.net/10568/76233

Haile, A., T. Getachew, T. Mirkena, G. Duguma, S. Gizaw, M. Wurzinger, J. Soelkner, O. Mwai, T. Dessie, A. Abebe, Z. Abate, T. Jembere, M. Rekik, R. N. B. Lobo, J. M. Mwacharo, Z. G. Terfa, G. T. Kassie, J. P. Mueller and B. Rischkowsky 2020. Community-based sheep breeding programs generated substantial genetic gains and socioeconomic benefits. animal: 1-9. doi: 10.1017/S1751731120000269

Haile, A., S. Gizaw, T. Getachew, J. P. Mueller, P. Amer, M. Rekik and B. Rischkowsky 2019. Community-based breeding programmes are a viable solution for Ethiopian small ruminant genetic improvement but require public and private investments. Journal of animal breeding and genetics 136: 319-328. doi: 10.1111/jbg.12401

Haile, A., M. Wurzinger, J. Mueller, T. Mirkena, G. Duguma, A. O. Mwai, J. Sölkner and B. A. Rischkowsky 2011. Guidelines for setting up community-based sheep breeding programs in Ethiopia: Lessons and experiences for sheep breeding in low-input systems. , 2nd ed.; ICARDA: Beirut, Lebanon.

Hamadou, I., N. Moula, S. Siddo, M. Issa, H. Marichatou, P. Leroy and N. Antoine-Moussiaux 2019. Valuing breeders' preferences in the conservation of the Koundoum sheep in Niger by multi-attribute analysis. Archives animal breeding 62: 537-545. doi: 10.5194/aab-62-537-2019

ILRI 2008. Climate, livestock and poverty. Challenges at the interface. In Climate, livestock and poverty. Challenges at the interface. Nairobi, Kenya: International Livestock Research Institute.

INSD 2018. Annuaire statistique. In Annuaire statistique, ed. Institut National de la Statistique et de la Demographie. Ministere de l´Economie et des fiancnes. Ouagadougou. Burkina Faso. Available online: http://www.insd.bf/n/contenu/pub_periodiques/annuaires_stat/Annuaires_stat_nationaux_BF/Annuaire_Statistique_National_2018.pdf (accessed on 10 July 2020).

Kassie, G. T., A. Abdulai and C. Wollny 2011. Heteroscedastic hedonic price model for cattle in the rural markets of central Ethiopia. Applied Economics 43: 3459-3464. doi: 10.1080/00036841003670614

Kaumbata, W., L. Banda, G. Mészáros, T. Gondwe, M. J. Woodward-Greene, B. D. Rosen, C. P. Van Tassell, J. Sölkner and M. Wurzinger 2020. Tangible and intangible benefits of local goats rearing in smallholder farms in Malawi. Small Ruminant Research 187: 106095. doi: https://doi.org/10.1016/j.smallrumres.2020.106095

Kielland, C., E. Skjerve, O. Østerås and A. J. Zanella 2010. Dairy farmer attitudes and empathy toward animals are associated with animal welfare indicators. Journal of Dairy Science 93: 2998-3006. doi: https://doi.org/10.3168/jds.2009-2899

Kinkpé, T. A., Rodrigue V. C. Diogo, Cokou P. Kpadé, Jacob A. Yabi and Luc H. Dossa 2019. The role of cattle attributes in buyers' choices in Benin. African Journal of Agricultural and Resource Economics 14: 56-71.

Kosgey, I. S., R. L. Baker, H. M. J. Udo and J. A. M. van Arendonk 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Ruminant Research 61: 13-28.

Kosgey, I. S. and A. M. Okeyo 2007. Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. Small Ruminant Research 70: 76-88. doi: https://doi.org/10.1016/j.smallrumres.2007.01.007

Kuivanen, K. S., S. Alvarez, M. Michalscheck, S. Adjei-Nsiah, K. Descheemaeker, S. Mellon-Bedi and J. C. J. Groot. 2016. Characterising the diversity of smallholder farming systems and their constraints and opportunities for innovation: A case study from the Northern Region, Ghana. NJAS - Wageningen Journal of Life Sciences 78: 153-166. doi: https://doi.org/10.1016/j.njas.2016.04.003

Laborde, D., S. Murphy, M. Parent, J. Porciello & C., Smaller. 2020. Ceres2030: Sustainable solutions to end hunger - Summary report. Cornell University, IFPRI and IISD: New York, NY, USA.

Leroy, G., R. Baumung, P. Boettcher, B. Scherf and I. Hoffmann 2015. Review: Sustainability of crossbreeding in developing countries; definitely not like crossing a meadow…. animal 10: 262-273. doi: 10.1017/S175173111500213X

Locabreed 2015-2020. Local Cattle Breeds of Burkina Faso – Characterization and Sustainable Utilization (LoCaBreed), 2014-2020. In Local Cattle Breeds of Burkina Faso – Characterization and Sustainable Utilization (LoCaBreed). Available online: https://appear.at/en/projects/current-projects/project-websites/project120-locabreed/ (accessed on 20 November 2020).

Madalena, F. E., K. Agyemang, R. C. Cardellino and G. L. Jain 2002. Genetic improvement in medium-to low-input systems of animal production. Experiences to date. In Proceedings of the 7th World Congress on Genetic Applied to Livestock Production, Montepellier, France, 19-23 August 2002, 331-340.

Martin-Collado, D., C. Diaz, G. Benito-Ruiz, D. Ondé and A. Rubio and T. J. Byrne. 2020. Measuring farmers´attitude towards breeding tools: the Livestock Breeding Attitude Scale. Animal: An International Journal of Animal Bioscience. doi: https://doi.org/10.1016/j.animal.2020.100062

Mavedzenge, B. Z., J. Mahenehene, F. Murimbarimba, I. Scoones and W. Wolmer. 2006. Changes in the livestock sector in Zimbabwe following land reform: the case of Masvingo province. Institute for Development Studies, Brighton, available from: http://www. ids. ac. uk/index. cfm.

Meijer, S. S., D. Catacutan, O. C. Ajayi, G. W. Sileshi and M. Nieuwenhuis. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability 13: 40-54. doi: 10.1080/14735903.2014.912493

Mirkena, T., G. Duguma, A. Willam, M. Wurzinger, A. Haile, B. Rischkowsky, A. M. Okeyo, M. Tibbo and J. Solkner. 2012. Community-based alternative breeding plans for indigenous sheep breeds in four agro-ecological zones of Ethiopia. Journal of Animal Breeding and Genetics 129: 244-253. doi: https://doi.org/10.1111/j.1439-0388.2011.00970.x

Mopaté, L. Y., M. J. B. Kamuanga, S. Hamadou and C. Y. Kaboré-Zoungrana 2014. Evaluation des pratiques paysannes de conservation in situ du taurin Baoulé au Sud-Ouest du Burkina

Faso. Animal Genetic Resources/Ressources génétiques animales/Recursos genéticos animales 54: 171-178. doi: 10.1017/S2078633614000022

Mrode, R., J. Han, J. Mwacharo, D. J. De Koning. 2016. Novel tools to inform animal breeding programs. Livestock and Fish Brief 14; ILRI: Nairobi, Kenya.

Mueller, J. P., B. Rischkowsky, A. Haile, J. Philipsson, O. Mwai, B. Besbes, A. Valle Zárate, M. Tibbo, T. Mirkena, G. Duguma, J. Sölkner and M. Wurzinger. 2015. Community-based livestock breeding programmes: essentials and examples. Journal of Animal Breeding and Genetics 132: 155-168. doi: 10.1111/jbg.12136

Mutenje, M., U. Chipfupa, W. Mupangwa, I. Nyagumbo, G. Manyawu, Irenie Chakoma and L. Gwiriri. 2020. Understanding breeding preferences among small-scale cattle producers: implications for livestock improvement programmes. animal 14: 1757-1767.

Mwacharo, J. M. and A. G. Drucker. 2005. Production Objectives and Management Strategies of Livestock Keepers in South-East Kenya: Implications for a Breeding Programme. Tropical Animal Health and Production 37: 635-652. doi: 10.1007/s11250-005-4253-8

Oldenbroek, K.; L. Van der Waaij. 2014. Textbook Animal Breeding: Animal Breeding and Genetics for BSc Students; Centre for Genetic Resources and Animal Breeding and Genomics Group,Wageningen University and Research Centre: Wageningen, The Netherlands, 2014; 311p, Available online: https://edepot.wur.nl/365431 (accessed on 17 July 2020).

Ouma, E., A. Abdulai and A. Drucker 2007. Measuring Heterogeneous Preferences for Cattle Traits among Cattle-Keeping Households in East Africa. American Journal of Agricultural Economics 89: 1005-1019. doi: https://doi.org/10.1111/j.1467-8276.2007.01022.x

Ouédraogo, D., A. Soudré, S. Ouédraogo-Koné, B. Zoma, B. Yougbaré, N. Khayatzadeh, P. Burger, G. Mészáros, A. Traoré, O. Mwai, M. Wurzinger and J. Sölkner 2019. Breeding objectives and practices in three local cattle breed production systems in Burkina Faso with implication for the design of breeding programs. Livestock Science 232: 103910. doi: 10.1016/j.livsci.2019.103910

Ouédraogo, D., S. Ouédraogo-Koné, B. Yougbaré, A. Soudré, B. Zoma-Traoré, G. Mészáros, N. Khayatzadeh, A. Traoré, M. Sanou, O. A. Mwai, M. Wurzinger, P. A. Burger and J. Sölkner 2021. Population structure, inbreeding and admixture in local cattle populations managed by community-based breeding programs in Burkina Faso. Journal of Animal Breeding and Genetics n/a. doi: https://doi.org/10.1111/jbg.12529

Porter, V., L. Alderson, S.J.G. Hall and D. P. Sponenberg. 2016. Mason's World Encyclopedia of Livestock Breeds and Breeding, 2 Volume Pack: Cabi pp.1021

Rege, J. E. O. 1999. The state of African cattle genetic resources I. Classification framework and identification of threatened and extinct breeds. Animal Genetic Resources Information 25: 1-25. doi: 10.1017/S1014233900003448

Rege, J. E. O., K. Marshall, A. Notenbaert, J. M. K. Ojango and A. M. Okeyo. 2011. Pro-poor animal improvement and breeding — What can science do? Livestock Science 136: 15-28. doi: 10.1016/j.livsci.2010.09.003

Rewe, T. O., P. Herold, A. K. Kahi and, A. V. Zárate. 2009. Breeding Indigenous Cattle Genetic Resources for Beef Production in Sub-Saharan Africa. Outlook on Agriculture 38: 317-326. doi: 10.5367/000000009790422205

Robinson, T. P., P. K. Thornton, G. Franceschini, R. L. Kruska, F. Chiozza, A. Notenbaert, G. Cecchi, M. T. Herrero, M. Epprecht, S. Fritz, L. You, G. Conchedda and, L. See. 2011. Global livestock production systems: Rome, Food and Agriculture Organization (FAO) and International Livestock Research Institute (ILRI), 152pp.

Roschinsky, R., M. Kluszczynska, J. Sölkner, R. Puskur and M. Wurzinger. 2015. Smallholder experiences with dairy cattle crossbreeding in the tropics: from introduction to impact. Animal 9: 150-157. doi: 10.1017/S1751731114002079

Ruto, E., G. Garrod and R. Scarpa. 2008. Valuing animal genetic resources: a choice modeling application to indigenous cattle in Kenya. Agricultural Economics 38: 89-98. doi: https://doi.org/10.1111/j.1574-0862.2007.00284.x

Siddo, S., N. Moula, I. Hamadou, M. Issa, H. Marichatou, P. Leroy and N. Antoine-Moussiaux. 2015. Breeding criteria and willingness to pay for improved Azawak zebu sires in Niger. Archives Animal Breeding 58: 251-259. doi: 10.5194/aab-58-251-2015

Soudré, A., S. Ouédraogo-Koné, M. Wurzinger, S. Müller, O. Hanotte, A. G. Ouédraogo and J. Sölkner. 2013. Trypanosomosis: a priority disease in tsetse-challenged areas of Burkina Faso. Tropical animal health and production 45: 497-503. doi: 10.1007/s11250-012-0248-4

Sölkner, J., H. Nakimbugwe and A. V. Zárate. 1998. Analysis of determinants for success and failure of village breeding programmes. In Analysis of determinants for success and failure of village breeding programmes, Proceedings of the 6th world congress on genetics applied to livestock production, 273-281. Armidale, New England: University of New England.

Traoré, S. A., A. Markemann, C. Reiber, H. P. Piepho and A. V. Zárate 2017. Production objectives, trait and breed preferences of farmers keeping N'Dama, Fulani Zebu and crossbred cattle and implications for breeding programs. animal 11: 687-695. doi: 10.1017/S1751731116002196

Wollny, C. B. A. 2003. The need to conserve farm animal genetic resources in Africa: should policy makers be concerned? Ecological Economics 45: 341-351.

Wurzinger, M., D. Ndumu, R. Baumung, A. Drucker, A.M. Okeyo, D.K. Semambo, and N. Byamungu. 2006. Comparison of production systems and selection criteria of Ankole cattle by breeders in Burundi, Rwanda, Tanzania and Uganda. Tropical Animal Health and Production 38, 571–581. https://doi.org/10.1007/s11250-006-4426-0

Wurzinger, M., J. Sölkner and L. Iñiguez. 2011. Important aspects and limitations in considering community-based breeding programs for low-input smallholder livestock systems. Small Ruminant Research 98: 170-175. doi: https://doi.org/10.1016/j.smallrumres.2011.03.035

Zoma-Traoré, B., S. Ouédraogo-Koné, A. Soudré, D. Ouédraogo, B. Yougbaré, A. Traoré, N. Khayatzadeh, G. Mészáros, P.A. Burger, A.M. Mwai, J. Sölkner, M. Wurzinger and L. Probst Under review. Values and beliefs that shape cattle breeding in south-western Burkina Faso. Human Ecology.

Zoma-Traoré, B., A. Soudré, S. Ouédraogo-Koné, N. Khayatzadeh, L. Probst, J. Sölkner, G. Mészáros, P. A. Burger, A. Traoré, M. Sanou, G. M. S. Ouédraogo, L. Traoré, D. Ouédraogo, B. Yougbaré and M. Wurzinger 2020. From farmers to livestock keepers: a typology of cattle production systems in south-western Burkina Faso. Tropical animal health and production. doi: 10.1007/s11250-020-02241

CHAPTER V

General discussion and conclusions

I. Introduction

Community-based breeding programs (CBBP) are a new approach of genetic improvement for low input traditional smallholder farming systems with farmers within limited geographic boundaries having a common interest to improve and share their genetic resources (Mueller et al., 2015; Sölkner et al., 1998; Wurzinger et al., 2011). CBBPs have been successfully implemented for sheep, goats, and pigs (Mirkena et al., 2012; Ojango et al., 2010; Roessler et al., 2012). The success of the breeding programs for goats and sheep in Ethiopia supported its adoption as a national policy and an invitation of the private sector to invest in CBBPs (Haile et al., 2020).

FAO (2007) raised the awareness about the reduction of the population of some breeds and among them, some were classified as endangered. Furthermore, FAO (2013, 2015) recommended in vitro as well as in situ conservation of endangered breeds. Lobi breed is known as a trypanoresistant cattle breed in Burkina Faso. Besides, it is adapted to the harsh environment. The breed is well known and mostly kept for its socio-cultural and spirituals functions of the Lobi ethnic group (De Rouville, 1987; Mopaté et al., 2014; Soro et al., 2015). Besides these qualities and functions, previous studies reported the crossbreeding of this breed with Fulani zebu which threatens this breed (Soudré et al., 2013). (Mopaté et al., 2014) investigated the efforts in situ of the conservation of the Lobi taurine breed. They found out that Lobi farmers are willing to participate in conservation efforts. In response to the indiscriminate crossbreeding the project named Locabreed "Local Cattle Breed-Burkina Faso-Characterization for sustainable utilization" was formulated and implemented by a consortium of scientists from Austria, Burkina Faso, and Kenya. One of the objectives of this project was to initiate sustainable breeding and conservation programs for Lobi and Zebu X Lobi crosses using a community-based breeding approach.

One of the important steps, as reported in previous studies, of the implication of CBBP is the understanding of the current production systems and farmer´s needs (Dossa et al., 2009; Kruska et al., 2003; Robinson et al., 2011; Sheriff et al., 2020; Sölkner et al., 1998). The description of the production system is usually the first step in the design of any breeding strategy (Mueller et al., 2015). Therefore, in the second chapter of this thesis a typology of production systems at the farm level in Southwestern Burkina Faso was developed. Moreover, successful implementation of the CBBPs should consider some social factors such as the values, beliefs, and norms of the farmers that can affect the implementation and the running of the breeding program (Martin-Collado et al., 2018; Wurzinger and Gutierrez, 2017). The third chapter of this thesis contributed to explore the values, beliefs, and norms that can shape the cattle breeding program in Southwestern Burkina Faso. The importance of the perception and the attitudes of the farmers towards the breeding tools were reported as an important aspect of the

implementation of the breeding program (Martin-Collado et al., 2020). Chapter four of the thesis has investigated and highlighted some attitudes of the farmers towards different breeding tools.

This present chapter summarizes the findings of the three chapters, discuss the implications and some conclusions are drawn.

II. Summary of the keys results

Chapter II explored the production system at farm level in Southwestern Burkina Faso.
The Factor analysis of mixed data and hierarchical clustering of the data from 169 farmers, suggested four production systems. The "Sedentary Lobi cattle farms" and the "Sedentary crossbreed farms" were mostly characterized by crop production-oriented farms and the ethnic group of the owners (Lobi ethnic group). The main difference between these two production systems remains the type of cattle breed. The dominant cattle breed is the Lobi cattle in the first system, whereas more crossbred cattle are kept in the second one. Another difference is the purpose of cattle, while in the "Sedentary Lobi cattle farms" cattle are used for plowing and socio-cultural events, they are used as savings and plowing in the "Sedentary crossbreed farms" syste,. The "Semi-transhumant Fulani zebu farms" and "Transhumant Fulani zebu farms" were described by more livestock keeping oriented farms and the ethnic group of the owners (Fulani ethnic group). Farmers from this group practice transhumance within and beyond the borders of the country. The main difference was the number of animals, as the herd sizes in the transhumant system were larger. The study revealed a change in the traditional roles of the different ethnic groups. Some of the crop-oriented Lobi farmers started with livestock keeping, whereas some of the Fulani pastoralists added crop production to their traditional livestock keeping. This shift in both groups can be explained by the interest of farmers to increase the basis of their livelihoods. Farmers across the four production systems characterized livestock keeping constrained by lack of water and pasture, diseases, and theft.
Chapter III contributed to understand the values, beliefs and norms that could affect and frame the cattle breeding program. Results highlighted that the insecure landscape and regime like the scarcity of land and resources, the weaknesses of the institution and the unreliable market lead farmers to secure their livelihood mainly by the diversification of their activities. Thus, *security* appeared as a prominent value of the respondents, followed by *achievement* which can be described by the number of cattle owned and the harvest from crop production achieved. *Conformity* to the social norms and past practices was also ranked high by farmers. *Power* related to *achievement* in terms of high output of their activities (crop production and animals) and *self-direction* when talking about the importance of education for the future generation were also some important values for the farmers.
Chapter four investigated the attitudes of the farmers towards breeding tools. The survey of 127 farmers reported the agreement of the majority of the farmers on the importance of the performance of the cattle compared to their appearance, maintaining the features of the different breeds and their willingness to participate in a breeders´ association. Although being member of an association was generally seen positive, there were heterogeneous opinions on the usefulness of bull sharing. In addition, some farmers didn´t see an advantage to record

performance data. Sharing of genetic material and data recording are two important pillars of any breeding program. These results indicate that these different viewpoints have to be addressed to ensure full participation of farmers in a breeding program. Participants had varying opinions about crossbreeding.

III. Implications of the results

3.1. Livelihood strategies of farmers are evolving

One of the important results of this thesis is that a strict linking of livestock keeping or crop production to a specific ethnic group is no more valid. Lobi farmers keep cattle now for a more economic than socio-cultural purpose. This points to a change in the production orientation of Lobi farmers from crop producers to livestock keepers. Risk mitigation and diversification of the activities to secure the livelihood led farmers to diversify their activities and increase their engagement to some neglected activities i.e. livestock keeping which remains as a secondary activity (Koutou et al., 2016; Ouédraogo et al., 2010). Crossbreeding was reported as a strategy to spread the risk by diversifying the breeds (Ayantunde et al., 2007). As the Lobi farmers become more interested in livestock keeping, they also realize that there are some constraints. Among these constraints, can be highlighted the lack of pasture and water, increase of the prevalence of diseases and parasites, theft, and conflict between farmers and livestock keepers. Many researchers also reported these constraints in their studies (Mopaté et al., 2014; Soro et al., 2015; Soudré et al., 2013). The Lobi farmers also reported insufficient technical knowledge to manage their herd for that they request the Fulani, considered like herder by default, to manage their herd. These animals are often herded together with Fulani Zebu from the herder. This practice supports the crossbreeding between these two local breeds which threatens the Lobi cattle breed (Dossa and Vanvanhossou, 2016; Mopaté et al., 2014). Any effort to implement a breeding program should address some constraints raised by farmers (Baker and Gray, 2004; Kosgey et al., 2008). The transition from livestock user to livestock keeper or even breeder in the Lobi community could be an opportunity and should be considered during the implementation of the breeding programs. Furthermore, the important number of Lobi taurine among the cattle owned by the Lobi farmers demonstrate their strong attachment to this breed which plays an important role in their social-cultural events (De Rouville, 1987; Soro et al., 2015). The transition of Lobi farmers associated with their attachment to the Lobi breed could favor its conservation via a breeding program. Mopaté et al. (2014) had reported the same observation in the region in an earlier study. A similar conclusion was drawn for the conservation of Somba breed by the Otammari people in Benin (Dossa and Vanvanhossou, 2016).

3.2. Take farmers' values, particularly security and achievement into account

In chapter three, farmers characterized their livelihood by describing their insecure circumstances. Thus, different strategies were adopted by farmers to mitigate this insecurity and to secure their livelihood. Among these strategies, the diversification of their activity was

the most common one. In terms of breeding, farmers kept in addition to the main mating bull at least two mating bulls as a backup. Previous studies in the region have already reported the vulnerability of livelihood of the farmers and their struggle to overcome it (Ayalew et al., 2003; Mwacharo and Drucker, 2005; Tano et al., 2001). Under these uncertain conditions some farmers are skeptical about sharing their selected bulls with others as reported previously by Traoré et al. (2017). This is in contrast with findings from Ayantunde et al. (2007) who reported that farmers were borrowing free of charge a good bull or were placing their cows in the bull´s herd for mating. However, our study mentioned some mistrust among farmers exists, which has to be overcome. Camara et al. (2019) also argued that promoting trust between stakeholders is the keystone of the sustainability of a breeding program. Nevertheless, farmers reported the existence of traditional sire exchange systems for small ruminants within a community and even the practice of sharing cattle for plowing between very close relatives. Studies on goats (Sheriff et al., 2020) and sheep (Haile et al., 2014) in Ethiopia have reported a tradition to borrow or share the sire within communities. This result shows again the importance of cattle compared to small ruminants in terms of cost assessment. One important implication of these findings for a breeding program is to seek a strategy that reduces risks or uncertainty encountered by farmers. Alternative insurance schemes for members of a breeding organization could help to solve this problem. A breeding program should also explore different strategies leading to genetic resource sharing among farmers. These strategies should be discussed and decided by the farmers based on their tradition and their experience. Different strategies can be applied to different groups of farmers based on their agreement.

Another finding is the importance of immediate and tangible outcomes of the breeding program before farmers committed themselves to a full engagement. Therefore, farmers demand visible improvement in their herds for any further commitment in the breeding program (Ayantunde et al., 2007; Ayantunde et al., 2020). The implication of this finding for the breeding program is to achieve some immediate results that could keep farmers interested and to ensure positive results in the long run.

It can be concluded that additional risk mitigation strategies have to be discussed with farmers and integrated into a breeding program.

3.3. Success factors of breeding programs

Chapter four investigated the attitudes of the farmers towards the different breeding tools. This investigation revealed the agreement of the farmers to keep the features of the different breeds and they valued more the performance of the animals than their appearance. This has been document by a previous study in the same region (Ouédraogo et al., 2019). Along the same argument previous study in Uganda has reported that farmers valued the performance of Ankole cattle compared to its appearance (Wurzinger et al., 2006).

However, farmers had diverse opinions on crossbreeding. For some farmers crossbreeding is a strategy to improve performance by combining trypanosomiasis resistance of Lobi breed and the productivity of the Fulani breed. Farmers argue that crossbred animals are more profitable, are better marketable than Lobi cattle and more adapted and required less health care than the Fulani cattle. That also supports the strategy of the project “Locabreed” to implement a breeding

program of pure Lobi and crossbred animals. Similar recommendations were made in the earlier studies for sheep and goats (Baker and Gray, 2004) and cattle (Leroy et al., 2015; Traoré et al., 2017). That could strengthen the engagement of the farmers to both breeding programs, also encouraging farmers who are involved in the pure breeding program to provide better bulls for the crossbreeding program.

All the farmers regardless the different production system agreed with the importance of breeders´ association. The importance of such association for the sustainability of the breeding program has been reported by Gutu et al. (2015). However, farmers were less inclined when it comes to fulfill the duties of being member of the association such as bull sharing. Therefore, the establishment of a breeders´ association with clear obligation and role are important elements to be considered for the sustainability in the long run.

References of chapter I and V

Asfaw, S., B. Shiferaw, F. Simtowe and L. Lipper. 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food policy 37: 283-295.

Ayalew, W., B. Rischkowsky, J. M. King and E. Bruns. 2003. Crossbreds did not generate more net benefits than indigenous goats in Ethiopian smallholdings. Agricultural Systems 76: 1137-1156. doi: https://doi.org/10.1016/S0308-521X(02)00033-1

Ayantunde, A. A., M. Kango, P. Hiernaux, H. M. J. Udo and R. Tabo. 2007. Herders' Perceptions on Ruminant Livestock Breeds and Breeding Management in Southwestern Niger. Human Ecology 35: 139-149. doi: 10.1007/s10745-006-9049-6

Ayantunde, A. A., B. O. Oluwatosin, V. Yameogo and M. van Wijk. 2020. Perceived benefits, constraints and determinants of sustainable intensification of mixed crop and livestock systems in the Sahelian zone of Burkina Faso. International Journal of Agricultural Sustainability 18: 84-98. doi: 10.1080/14735903.2019.1698494

Baker, R.L.and G.D. Gray. 2004. Appropriate breeds and breeding schemes for sheep and goats in the tropics: the importance of characterizing and utilizing disease resistance and adaptation to tropical stresses. In: Sani, R.A., Gray, G.D., Baker, R.L. (Eds.), Worm Control for Small Ruminants in Tropical Asia, Monograph 113. Australian Centre for International Agricultural Research (ACIAR), pp. 63–95.

Belemsaga, D. M. A., Y. Lombo, S. Thevenon and S. Sylla. 2005. Inventory analysis of West African cattle breeds. In Applications of Gene-Based Technologies for Improving Animal Production and Health in Developing Countries, 167-173: Springer.

Brooks, S. and M. Loevinsohn. 2011. Shaping agricultural innovation systems responsive to food insecurity and climate change. Natural Resources Forum 35: 185-200. doi: 10.1111/j.1477-8947.2011.01396.x

Brown, L.A., M. Webber and J.M. Lutz. 1981. Innovation diffution: A new perspective. London: Methuen. Progress in Human Geography, 30 (4), 487-489.

Camara, Y., M. Ciss, N. Moula, M. M. Sissokho, F. Farnir and N. Antoine-Moussiaux. 2019. Determinants of breeders' participation to an indigenous cattle breeding program. Agronomy for Sustainable Development 39: 44. doi: 10.1007/s13593-019-0591-1

Chambers, R., A. Pacey and L. A. Thrupp. 1989. Farmer first: farmer innovation and agricultural research. London: Technology Publications, pp.218.

Chambers, R., A. and B. P. Ghildyal. 1985. Agricultural research for resource-poor farmers: The farmer-first-and-last model. Agricultural Administration 20: 1-30. doi: https://doi.org/10.1016/0309-586X(85)90063-9

Chapman, J. 2004. System failure: Why governments must learn to think differently (2nd ed.). London, UK: Demos.

Darnhofer, I., D. Gibbon and B. Dedieu. 2012. Farming Systems Research: an approach to inquiry. In Farming Systems Research into the 21st Century: The New Dynamic, eds. Ika Darnhofer, David Gibbon and Benoît Dedieu, 3-31. Dordrecht: Springer Netherlands.

De Haan, C., E. Dubern, B. Garancher and, C. Quintero. 2016. Pastoralism development in the Sahel: A road to stability?: World Bank, Washington, DC. World Bank. p.37 https://openknowledge.worldbank.org/handle/10986/24228

De Janvry, A. and E. Sadoulet. 2002. World Poverty and the Role of Agricultural Technology: Direct and Indirect Effects. The Journal of Development Studies 38: 1-26. doi: 10.1080/00220380412331322401

De Rouville, C. 1987. Organisation sociale des Lobi: une societe bilineaire du Burkina Faso et de Cote d'Ivoire; L'Harmattan: Paris, France, pp.259.

Dessie, T. and A. O. Mwai. 2019. The story of cattle in Africa: Why diversity matters. In The story of cattle in Africa: Why diversity matters: ILRI, Rural Development Administration, Republic of Korea and AU-IBAR. Available online: https://hdl.handle.net/10568/108945 (accessed on 7 September 2020).

Dossa, L. H., C. Wollny, M. Gauly and, I. Gbégo. 2009. Community-based management of farm animal genetic resources in practice: framework for focal goats in two rural communities in Southern Benin. Animal Genetic Resources Information 44: 11-31. doi: 10.1017/S1014233900002832

Dossa, L. H., M. Sangaré, A. Buerkert and, E. Schlecht. 2015. Intra-urban and peri-urban differences in cattle farming systems of Burkina Faso. Land Use Policy 48: 401-411. doi: https://doi.org/10.1016/j.landusepol.2015.06.031

Dossa, L. H. and F. U. S. Vanvanhossou. 2016. The indigenous Somba cattle of the hilly Atacora region in North-West Benin: threats and opportunities for its sustainable use. Tropical animal health and production 48: 349-359.

Duguma, G., T. Mirkena, A. Haile, A. M. Okeyo, M. Tibbo, B. Rischkowsky, J. Sölkner and, M. Wurzinger. 2011. Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: choice model approach. Animal 5: 1984-1992. doi: 10.1017/s1751731111001029

Eagly, A. H. and S. Chaiken. 1993. The psychology of attitudes: Harcourt brace Jovanovich college publishers.

FAO. 2010. Breeding Strategies for Sustainable Management of Animal Genetic Resources; FAO Animal Production and Health Guidelines. No 3.; FAO: Rome, Italy, p. 132. Available online: http://www.fao.org/3/i1103e/i1103e.pdf (accessed on 7 September 2020).

FAO. 2013. In Vivo Conservation of Animal Genetic Resources. FAO Animal Production and Health Guidelines.No.14.; FAO: Rome, Italy, p.235. Available online: http://www.fao.org/3/i3327e/i3327e.pdf (accessed on 12 July 2019).

FAO. 2019. Le devenir de l'élevage au Burkina Faso. Défis et opportunités face aux incertitudes. Rome, Italy, 56p. Available online:http://www.fao.org/3/ca4952fr/ca4952fr.pdf (accessed on 15 October 2020).

FAO. 2018. Le dévelopement durable de l´élevage africain: approche «Une seule santé » au Burkina Faso. Rome, Italy, 104p. Available online: http://www.fao.org/3/ca1084fr/ca1084fr.pdf (Accessed on 20 April 2020).

FAO 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Rome, Italy: FAO Commission on Genetic Resources for Food and Agriculture Assessments. 12p. Available online: http://www.fao.org/3/i5077e/i5077e.pdf (Accessed on 7 March 2019).

FAO 2007. The state of the world's animal genetic resources for food and agriculture – in brief, edited by Dafydd Pilling & Barbara Rischkowsky. Rome, Italy: Food & Agriculture Org. Available online: http://www.fao.org/3/a1260e/a1260e.pdf (Accessed on 14 May 2019).

Feder, G. and D. L. Umali. 1993. The adoption of agricultural innovations: a review. Technological forecasting and social change 43: 215-239.

Fiéloux, M. 1980. Les sentiers de la nuit: les migrations rurales lobi de la Haute-Volta vers la Côte d'Ivoire. Vol. 110. IRD Editions.

Gatzweiler, F. W. and J. Von Braun. 2016. Technological and institutional innovations for marginalized smallholders in agricultural development. p. 435. Springer Nature.

Gibon, A., A. R. Sibbald, J. C. Flamant, P. Lhoste, R. Revilla, R. Rubino and, J. T. Sørensen. 1999. Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming. Livestock Production Science 61: 121-137. doi: https://doi.org/10.1016/S0301-6226(99)00062-7

Grace, D., E. Patel and, T. F. Randolph. 2020. Tsetse and Trypanosomiasis Control in West Africa, Uganda and Ethiopia: ILRI's Role in the Field. In The Impact of the International Livestock Research Institute, eds. John McIntire and Delia Grace, Nairobi, Kenya: ILRI, and Wallingford, UK: CABI. pp. 148.

Haile, A., T. Dessie and, B. A. Rischkowsky. 2014. Performance of indigenous sheep breeds managed under community-based breeding programs in the highlands of Ethiopia: Preliminary results. Addis Ababa: ICARDA: hdl.handle.net/ 10568/35466

Haile, A., T. Getachew, T. Mirkena, G. Duguma, S. Gizaw, M. Wurzinger, J. Soelkner, O. Mwai, T. Dessie, A. Abebe, Z. Abate, T. Jembere, M. Rekik, R. N. B. Lobo, J. M. Mwacharo, Z. G. Terfa, G. T. Kassie, J. P. Mueller and, B. Rischkowsky 2020. Community-based sheep breeding programs generated substantial genetic gains and socioeconomic benefits. animal: 1-9. doi: 10.1017/S1751731120000269

Haile, A., S. Gizaw, T. Getachew, J. P. Mueller, P. Amer, M. Rekik and B. Rischkowsky. 2019. Community-based breeding programmes are a viable solution for Ethiopian small ruminant genetic improvement but require public and private investments. Journal of animal breeding and genetics 136: 319-328. doi: 10.1111/jbg.12401

Haile, A., M. Wurzinger, J. Mueller, T. Mirkena, G. Duguma, A. O. Mwai, J. Sölkner and B. A. Rischkowsky. 2011. Guidelines for setting up community-based sheep breeding programs in Ethiopia: Lessons and experiences for sheep breeding in low-input systems, 2nd ed.; ICARDA: Beirut, Lebanon, 2011.

Henry, S., V. Piché, D. Ouédraogo and E. F. Lambin. 2004. Descriptive Analysis of the Individual Migratory Pathways According to Environmental Typologies. Population and Environment 25: 397-422. doi: 10.1023/B:POEN.0000036929.19001.a4

Islam, T. 2014. Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. Energy Policy 65: 340-350. doi: https://doi.org/10.1016/j.enpol.2013.10.004

Jarrett, F. G. 1985. Sources and models of agricultural innovation in developed and developing countries. Agricultural Administration 18: 217-234. doi: 10.1016/0309-586X(85)90092-5

Kamuanga M, G.D.M d'Ieteren, K. Tano, M.A. Jabbar, B.M. Swallow and K. Pokou. 1999. Farmer preferences of cattle breeds, their market values and prospects for improvement in West Africa: a summary review. In Proceedings of the 25th Meeting of the International Scientific Council for Trypanosomiasis Research and Control, Mombasa, Kenya, 27 September to 2 October 1999 (ed. KR Sones), pp. 271–298. Organization of African Unity/International Scientific Council for Trypanosomiasis Research and Control, Publication No. 120, Nairobi, Kenya.

Kassie, M., B. Shiferaw and G. Muricho. 2011. Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda. World Development 39: 1784-1795. doi: 10.1016/j.worlddev.2011.04.023

Kinkpé, T. A., R. V. C. Diogo, C. P. Kpadé, J. A. Yabi and, L. H. Dossa. 2019. The role of cattle attributes in buyers' choices in Benin. African Journal of Agricultural and Resource Economics 14 (1): 56-71. doi: https://doi.org/10.22004/ag.econ.287195

Klerkx, L., B. van Mierlo and C. Leeuwis. 2012. Evolution of systems approaches to agricultural innovation: concepts, analysis and interventions. In Farming Systems Research into the 21st Century: The New Dynamic, eds. Ika Darnhofer, David Gibbon and Benoît Dedieu, 457-483. Dordrecht: Springer Netherlands.

Kosgey, I. S., R. L. Baker, H. M. J. Udo and, J. A. M. van Arendonk. 2006. Successes and failures of small ruminant breeding programmes in the tropics: a review. Small Ruminant Research 61: 13-28.

Kosgey, I. S., G. J. Rowlands, J. A. M. van Arendonk and, R. L. Baker. 2008. Small ruminant production in smallholder and pastoral/extensive farming systems in Kenya. Small Ruminant Research 77: 11-24. doi: https://doi.org/10.1016/j.smallrumres.2008.02.005

Koutou, M., M. Sangaré, M. Havard, E. Vall, L. Sanogo, T. Thombiano and, D. S. Vodouhe. 2016. Adaptation des pratiques d'élevage des producteurs de l'Ouest du Burkina Faso face aux contraintes foncières et sanitaires. Agronomie Africaine 28: 13-24.

Kruska, R. L., R. S. Reid, P. K. Thornton, N. Henninger and, P. M. Kristjanson. 2003. Mapping livestock-oriented agricultural production systems for the developing world. Agricultural Systems 77: 39-63. doi: https://doi.org/10.1016/S0308-521X(02)00085-9

Leroy, G., R. Baumung, P. Boettcher, B. Scherf and, I. Hoffmann. 2015. Review: Sustainability of crossbreeding in developing countries; definitely not like crossing a meadow…. animal 10: 262-273. doi: 10.1017/S175173111500213X

MAHRH 2011. Cadre d´action pour l´investissement agricole au Burkina Faso. In Cadre d´action pour l´investissement agricole au Burkina Faso., ed. de l´Hydraulique et des Ressources Halieutiques. Ministere de l´Agriculture, 88. Ouagadougou, Burkina Faso.

Markemann, A. and A. V. Zárate 2009. Traditional llama husbandry and breeding management in the Ayopaya region, Bolivia. Tropical Animal Health and Production 42: 79-87. doi: 10.1007/s11250-009-9388-6

Martin-Collado, D., T. J. Byrne, C. Diaz and, P. R. Amer. 2018. Complexity of animal breeding choice making. Journal of Animal Breeding and Genetics 135: 395-409. doi: 10.1111/jbg.12360

Martin-Collado, D., C. Diaz, G. Benito-Ruiz, D. Ondé and, A. Rubio and T. J. Byrne. 2020. Measuring farmers´attitude towards breeding tools: the Livestock Breeding Attitude Scale. Animal: An International Journal of Animal Bioscience. doi: https://doi.org/10.1016/j.animal.2020.100062

McIntyre, B. D., H. R. Herren, J. Wakhungu and, R. T. Watson. 2009. Agriculture at a Crossroads: Global Report pp. 590. Washington DC: International Assessment of Agricultural Knowledge Science and Technology for Development (IAASTD).

Meijer, S. S., D. Catacutan, C. A. Oluyede, W. S. Gudeta and M. Nieuwenhuis. 2015. The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability 13: 40-54. doi: 10.1080/14735903.2014.912493

Minot, N. and E.Samara 2020. Role of pastoralism in Burkina Faso: Contribution to revenue, food security, and resilience. SNV Voices for Change Partnership au Burkina Faso. 84p. Availableonline:https://snv.org/cms/sites/default/files/explore/download/role_of_livestock_report_en.pdf

Mirkena, T., G. Duguma, A. Willam, M. Wurzinger, A. Haile, B. Rischkowsky, A. M. Okeyo, M. Tibbo and, J. Solkner. 2012. Community-based alternative breeding plans for indigenous sheep breeds in four agro-ecological zones of Ethiopia. Journal of Animal Breeding and Genetics 129: 244-253. doi: https://doi.org/10.1111/j.1439-0388.2011.00970.x

Molina-Flores, B., P. Manzano-Baena and, M.D. Coulibaly. 2020. The role of livestock in food security, poverty reduction and wealth creation in West Africa. FAO. Accra. pp.203 https://doi.org/10.4060/ca8385en.

Mopaté, L. Y., M. J. B. Kamuanga, S. Hamadou and, C. Y. Kaboré-Zoungrana. 2014. Evaluation des pratiques paysannes de conservation in situ du taurin Baoulé au Sud-Ouest du Burkina Faso. Animal Genetic Resources/Ressources génétiques animales/Recursos genéticos animales 54: 171-178. doi: 10.1017/S2078633614000022

MRA 2003. Rapport national sur l´état des ressources génétiques animales au Burkina Faso. In Rapport national sur l´état des ressources génétiques animales au Burkina Faso., ed. Ministere des Ressources Animales, 73. Ouagadougou, Burkina Faso: Ministere des Ressources Animales.

Mueller, J. P., B. Rischkowsky, A. Haile, J. Philipsson, O. Mwai, B. Besbes, A. V. Zárate, M. Tibbo, T. Mirkena, G. Duguma, J. Sölkner and, M. Wurzinger. 2015. Community-based livestock breeding programmes: essentials and examples. Journal of Animal Breeding and Genetics 132: 155-168. doi: 10.1111/jbg.12136

Mwacharo, J. M. and A. G. Drucker. 2005. Production Objectives and Management Strategies of Livestock Keepers in South-East Kenya: Implications for a Breeding Programme. Tropical Animal Health and Production 37: 635-652. doi: 10.1007/s11250-005-4253-8

Norman, D. W. 2002. The farming systems approach: A historical perspective. In The farming systems approach: A historical perspective, Presentation held at the 17th Symposium of the International Farming Systems Association in Lake Buena Vista, Florida, USA, 17-20.

Nugteren, H., C. Le Côme. Libérer le Potentiel du Pastoralisme Pour Développer L'afrique de l'Ouest; Fred Zaal, Thea Hilhorst et Jacqueline Sluijs; KIT and SNV: Amsterdam, The Netherlands, 2016.

Ojango J.M.K., C. Ahuya, A.M.Okeyo, J.E.O Rege. 2010. The FARM-Africa dairy goat improvement project in Kenya: a case study. In: J.M. Ojango, B. Malmfors, A.M. Okeyo (eds), Animal Genetics Training Resource, version 3, 2011. International Livestock Research Institute, Nairobi, Kenya and Swedish University of Agricultural Sciences, Uppsala, Sweden.

Ouédraogo, D., A. Soudré, S. Ouédraogo-Koné, B. Zoma, B. Yougbaré, N. Khayatzadeh, P. Burger, G. Mészáros, A. Traoré, O. Mwai, M. Wurzinger and, J. Sölkner. 2019. Breeding objectives and practices in three local cattle breed production systems in Burkina Faso with implication for the design of breeding programs. Livestock Science 232: 103910. doi: 10.1016/j.livsci.2019.103910

Ouédraogo M., Y. Dembélé, L. Somé. 2010. Perceptions et stratégies d'adaptation aux changements des précipitations : cas des paysans du Burkina Faso. Science et changements planétaires / Sécheresse 21(2):87-96. doi:10.1684/sec.2010.0244

Paré, S., U. Söderberg, M. Sandewall and, J. M. Ouadba. 2008. Land use analysis from spatial and field data capture in southern Burkina Faso, West Africa. Agriculture, Ecosystems & Environment 127: 277-285. doi: https://doi.org/10.1016/j.agee.2008.04.009

Planchenault, D. 1987. L´élevage. In Elevage et potentialités pastorales sahéliennes. Syntheses cartographiques. Burkina Faso, ed. CIRAD-IEMVT-FRA, 18-22. Wageningen: CTA-CIRAD-IEMVT.

Rewe, T. O., P. Herold, A. K. Kahi and A. V. Zárate. 2009. Breeding Indigenous Cattle Genetic Resources for Beef Production in Sub-Saharan Africa. Outlook on Agriculture 38: 317-326. doi: 10.5367/000000009790422205

Rigolot, C., P. de Voil, S. Douxchamps, D. Prestwidge, M. Van Wijk, P. K. Thornton, D. Rodriguez, B. Henderson, D. Medina and M. Herrero. 2017. Interactions between intervention packages, climatic risk, climate change and food security in mixed crop–livestock systems in Burkina Faso. Agricultural Systems 151: 217-224. doi: https://doi.org/10.1016/j.agsy.2015.12.017

Robinson, T.P., P.K. Thornton, F. Gianluca, R.L. Kruska, F. Chiozza, A. Notenbaert, G. Cecchi, M. Herrero, M. Epprecht, S. Fritz, L. You, G. Conchedda & L. See. 2011. Global livestock production systems: FAO and ILRI. Rome, Italy/Nairobi, Kenya, 152pp.

Roessler, R. 2019. Selection Decisions and Trait Preferences for Local and Imported Cattle and Sheep Breeds in Peri-/Urban Livestock Production Systems in Ouagadougou, Burkina Faso. Animals 9(5) 207. doi: 10.3390/ani9050207

Roessler, R., P. Herold, H. Momm and, A.V. Zárate. 2012. Organisation of breeding under difficult framework conditions–the case of smallholder pig breeding in mountainous areas in Northwest Vietnam. Archives Animal Breeding 55 (6): 590-602.

Rogers, E. M. 1962. Bibliography on the Diffusion of Innovations. New York : Free Press of Glencoe. 367p.

Rogers, E. M. 2010. Diffusion of innovations Fourth Edition: Simon and Schuster. New York : The Free Press. 519p.

Rouville, C. 1984. Les cérémonies d'initiation du bur chez les Lobi de la région d'Iridiaka (Burkina Faso). Journal des Africanistes anc Journal de la Société des Africanistes Paris 54: 75-98.

Röling, N.G. 1990. The agricultural research-technology transfer interface: a knowledge systems perspective. in D Kaimowitz (ed.), Making the link; agricultural research and technology transfer in developing countries. pp. 1-42.

Schwartz, S. H. 1992. Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries. In Advances in Experimental Social Psychology, ed. Mark P. Zanna, 1-65: Academic Press.

Schwartz, S. H. and B. Wolfgang. 1987. Toward a universal psychological structure of human values. Journal of personality and social psychology 53(3): 550-562. https://doi.org/10.1037/0022-3514.53.3.550

Seymour, E., A. Curtis, D. Pannell, C. Allan and A. Roberts. 2010. Understanding the role of assigned values in natural resource management. Australasian Journal of Environmental Management 17: 142-153. doi: 10.1080/14486563.2010.9725261

Sheriff, O., A. Kefyalew and H. Aynalem. 2020. Production systems and breeding practices of Arab and Oromo goat keepers in Northwestern Ethiopia: Implications for community-based breeding programs. Tropical Animal Health and Production 52: 1467-1478. doi: 10.1007/s11250-019-02150-3

Snapp, S. and P. Barry. 2017. Agricultural systems: agroecology and rural innovation for development: agroecology and rural innovation for development: Academic Press. 400p.

Soni, R. P., M. Katoch and, R. Ladohia. 2014. Integrated farming systems-a review. Journal of Agriculture and Veterinary Science 7: 36-42.

Soro, B., D. P. Sokouri, G. K. Dayo, A. S. P. N'Guetta and, C. V. Yapi-Gnaoré. 2015. Caractérisation des bovins de race Baoulé dans le"Pays Lobi" de Côte d'Ivoire: rôles socio-économiques, modes d'élevage et contraintes de production. Tropicultura 33 (2): 111-124.

Soudré, A., S. Ouédraogo-Koné, M. Wurzinger, S. Müller, O. Hanotte, A. G. Ouédraogo and, J. Sölkner. 2013. Trypanosomosis: a priority disease in tsetse-challenged areas of Burkina Faso. Tropical Animal Health and Production 45: 497-503. doi: 10.1007/s11250-012-0248-4

Stern, P. C. 2000. Psychology and the science of human-environment interactions. American Psychologist 55: 523-530. doi: 10.1037/0003-066X.55.5.523

Stern, P. C., T. Dietz, T. Abel, G. A. Guagnano and, L. Kalof. 1999. A value-Belief-Norm theory of support for social movements: The case of environmentalism. Human ecology review 6 (2): 81-97.

Sölkner, J., H. Nakimbugwe and, A. Valle Zarate. 1998. Analysis of determinants for success and failure of village breeding programmes. In Analysis of determinants for success and failure of village breeding programmes, Proceedings of the 6th world congress on genetics applied to livestock production, 273-281. Armidale, New England: University of New England.

Tano, K., M. Kamuanga, M. D. Faminow and, B. M. Swallow. 2001. Adoption and demand for trypanotolerant cattle in the subhumide zone of West Africa. Journal of Agriculture and Environment for International development 95: 213-235.

Tarawali, G. and P. Hiernaux. 2002. Improving crop-livestock systems in the dry savannas of west and central Africa. In Improving crop-livestock systems in the dry savannas of west and central Africa, ed. IITA, Reports from the workshop on crop livestock systems in the dry savannas of West and Central Africa, 22-27 November 1998, 23-42. Ibanga, Nigeria: IITA.

Thornton, P.K., R.L. Kruska, N. Henninger, P.M. Kristjanson, R.S. Reid, F. Atieno, A.N. Odero and, T. Ndegwa. 2002. Mapping poverty and livestock in the developing world. 124p. Nairobi (Kenya): ILRI.

Traoré, A., D. O. Koudandé, I. Fernández, A. Soudré, V. Granda, I. Álvarez, S. Diarra, F. Diarra, A. Kaboré, M. Sanou, H. H. Tamboura, and F. Goyache. 2015. Geographical assessment of body measurements and qualitative traits in West African cattle. Tropical Animal Health and Production 47: 1505-1513. doi: 10.1007/s11250-015-0891-7

Traoré, S. A., A. Markemann, C. Reiber, H. P. Piepho, and A. Valle Zárate. 2017. Production objectives, trait and breed preferences of farmers keeping N'Dama, Fulani Zebu and crossbred cattle and implications for breeding programs. Animal 11: 687-695. doi: 10.1017/S1751731116002196

Vilaboa-Arroniz, J., P. Diaz-Rivera, O. Ruiz-Rosado, D.E. Platas-Rosado, S. González-Muñoz, and F. Juárez-Lagunes. 2008. Socioeconomical and technological characterization of agroecosystems with dual purpose cattle in the papaloapan region, Veracruz, Mexico. Tropical and Subtropical Agroecosystems 10: 53-62.

Von Bertalanffy, L. 1956. General system theory. General systems 1: 11-17.

Wurzinger, M., D. Ndumu, R. Baumung, A. Drucker, A.M. Okeyo, D.K. Semambo, and N. Byamungu. 2006. Comparison of production systems and selection criteria of Ankole cattle by breeders in Burundi, Rwanda, Tanzania and Uganda. Tropical Animal Health and Production 38, 571–581. https://doi.org/10.1007/s11250-006-4426-0

Wurzinger, M., J. Sölkner, and L. Iñiguez. 2011. Important aspects and limitations in considering community-based breeding programs for low-input smallholder livestock systems. Small Ruminant Research 98: 170-175. doi: https://doi.org/10.1016/j.smallrumres.2011.03.035

Wurzinger, M., L. Escareño, F. Pastor, H. Salinas, L. Iñiguez, and J. Sölkner. 2013. Design and implementation of a community-based breeding program for dairy goats in Northern Mexico. Tropical and Subtropical Agroecosystems 16 (2): 289-296.

Yougbaré, B., A. Soudré, D. Ouédraogo, B. L. Zoma, A. S. R. Tapsoba, M. Sanou, S. Ouédraogo-Koné, P. Burger, M. Wurzinger, N. Khayatzadeh, H. H. Tamboura, A. Traoré, J. Sölkner, and G. Mészáros. 2020. Morphometric characterization of purebred and crossbred Baoulé cattle in Burkina Faso. Acta Agriculturae Scandinavica, Section A — Animal Science 69: 193-202. doi: 10.1080/09064702.2020.1825785