sustainability

MDPI

Article

Vehicular Livestock Mobility in West Africa: Seasonal Traffic Flows of Cattle, Sheep, and Goats across Bamako

Louis Amprako [1], Hanna Karg [1,2], Regina Roessler [3], Jennifer Provost [3], Edmund Kyei Akoto-Danso [1], Seydou Sidibe [4] and Andreas Buerkert [1,*]

1 Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics (OPATS), University of Kassel, Steinstrasse 19, D-37213 Witzenhausen, Germany; amprako@outlook.com (L.A.); hanna.karg@gmx.de (H.K.); Kydanso07@yahoo.com (E.K.A.-D.)
2 Institute of Environmental Social Sciences and Geography, University of Freiburg, Physical Geography, Schreiberstraße 20, D-79085 Freiburg, Germany
3 Animal Husbandry in the Tropics and Subtropics, University of Kassel, Steinstrasse 19, D-37213 Witzenhausen, Germany; regina.roessler@uni-kassel.de (R.R.); jennifer.provost@gmail.com (J.P.)
4 Institut d'Economie Rurale (IER), Bamako, Mali; seydousidibe@hotmail.com
* Correspondence: buerkert@uni-kassel.de

Abstract: Mali is a major livestock producing country in West Africa. However, in recent years, the sector has faced multiple challenges like farmer-herder conflicts, overuse of grazing and water resources, and the effects of climate change. Meanwhile, traditional livestock systems are becoming less important given the increased availability of vehicular transport for regional and international animal trade as well as new opportunities for more specialised urban and peri-urban production systems. To assess the role of Mali's capital city Bamako for livestock consumption and trade, this study examined the scale of livestock movement in the city, comprising influxes, outfluxes, and transits. To this end, flows of cattle, small ruminants, and livestock feed were recorded through road surveys covering three different seasons. The results showed the role of Bamako as a major trade hub in the distribution of ruminants. While traffic of cattle and sheep was regional, movement of goats was smaller and more localised. Religious festivals were an important driver of livestock traffic, both in terms of the numbers of livestock and the distance covered. This study highlights the role of cities for livestock mobility and contributes to a better understanding of challenges related to urban livestock production and trade and its requirements for better livestock management.

Keywords: animal mobility; sub-Sahara Africa; truck distribution of livestock; animal feed

check for updates

Citation: Amprako, L.; Karg, H.; Roessler, R.; Provost, J.; Akoto-Danso, E.K.; Sidibe, S.; Buerkert, A. Vehicular Livestock Mobility in West Africa: Seasonal Traffic Flows of Cattle, Sheep, and Goats across Bamako. *Sustainability* **2021**, *13*, 171. https://dx.doi.org/10.3390/su13010171

Received: 23 November 2020
Accepted: 22 December 2020
Published: 26 December 2020

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

The West African Sahel is a semi-arid region located between the Sahara and the humid Savannah region. It is particularly vulnerable to food insecurity. Crop production in this region is severely limited by low soil fertility and aridity, and therefore, pastoralism is a popular feature of the Sahelian agriculture, contributing to food supply and income generation [1]. The risk of food insecurity in the Sahel is further exacerbated by rapid population growth [2]. Over millennia, Sahelian pastoralists have coevolved with their environment, migrating at the onset of the rainy season along fixed feeding corridors with their livestock to vast grasslands of the north and returning at its end to the south [3]. Together, transhumance and other types of livestock production provide about 20% of the caloric requirements of the Sahelian population [4], contribute up to 15% to the Gross Domestic Product (GDP), and provide income to over 40 million Sahelians [5]. Apart from its economic and nutritional contribution, livestock is also important for religious and cultural celebrations [4]. Livestock trade points have been established to facilitate livestock flows within the Sahel and across West Africa [6].

Mali is a major exporter of livestock throughout the Sahel region [7,8] and livestock trade contributes about 19% of the country's GDP [9]. For the last decade, livestock

production and trade has been threatened by violent conflicts [10]. In 2012, an uprising, involving Tuaregs, jihadists, and the government forces of Mali, led to a political coup, which triggered security interventions within the country and the entire Sahel region [10]. This affected the mobility of herders and their livestock, a constraint which will likely remain for years to come [11]. Another security concern are simmering tensions and sporadic attacks between the Fulani livestock herders and the Bambara and Dogon crop farmers over the use of the increasingly scarce land and water resources [12]. These conflicts over resources have been fueled by national policies favouring the development of crop farming over pastoralism since the country's independence [13] and the weak implementation of collective land use rights for pastoralists in the absence of land titles [14].

Currently, livestock trade in Mali mostly consists of live animals that are trekked to cities or large livestock markets, either for local consumption or for further export to coastal countries [15]. However, the limited access to grazing and water sources and the insecurity hindering livestock mobility have contributed to an expansion of vehicular long-distance transportation of live animals. Furthermore, traditional livestock farming systems are undergoing a gradual shift to more intensive sedentary livestock systems and to more specialised to milk or meat [16], partly monetarised economic systems [17]. Increasingly, such specialised livestock production systems prevail in and around larger cities and heavily rely on livestock feed from rural areas [16]. This evolution of traditional livestock production into specialised livestock systems focused on demand of urban areas stimulates livestock trading and as a result, urban centres in Africa are progressively becoming important trade hubs [18] while also playing an important role in urban livestock rearing [19]. For instance, Bamako harbours the largest livestock markets in the country and attracts large numbers of livestock for urban consumption and trade [20]. It is likely that due to the increasing demand for livestock products in urban areas across the region, the scale of livestock movements in cities of the Sahel will increase in terms of numbers as well as distance covered.

Information on the current scale of vehicular livestock movements into West African urban centres remains scarce despite its relevance towards the associated pressure on natural resources and the essential facilities that are needed to accommodate increasing numbers of animals in rapidly growing urban centres. To contribute to filling this research gap, this study examined overall vehicular livestock movements for (1) urban consumption, (2) redistribution, and (3) transits in Bamako during three different seasons. A particular focus was placed on the quantitative assessment of livestock flows and feed entering, leaving, and passing through the city whereby we recorded their geographical origin and destination.

2. Materials and Methods

2.1. Study Site Description

Following the Koeppen classification [21] the main cattle production areas of Mali are characterised by a hot desert climate whereby towns like Kidal, Gao, and Timbuktu are hottest during the dry season while rainfall increases southwards, comprising cities like Mopti, Ségou, and Bamako. The latter has a tropical savanna climate with a mean maximum temperature of 35 °C, a mean minimum temperature of 21 °C, and an annual rainfall of 991 mm [22]. At a population of 2.6 million, Bamako has one of Africa's fastest growth rates [23,24]. Due to its geographical location and its national relevance as Mali's capital, Bamako serves as a central trade hub for goods traded both within the country and in the sub-region. Therefore, we chose this city as a suitable study site to collect data on vehicular livestock mobility and to analyse influxes, outfluxes, and transits within the region.

2.2. Methods

2.2.1. Collection of Primary Data on Flows of Livestock and Livestock Feed

From 11/2015 to 8/2017 information on the movement of cattle, sheep, and goats as well as the flows of livestock feed into the city was recorded on all major and minor access roads to the city of Bamako (Figure 1). Given the strong seasonality of livestock movements and livestock feed transports, the surveys were carried out in three different seasons representing the hot dry season, the rainy season, and the harvest season.

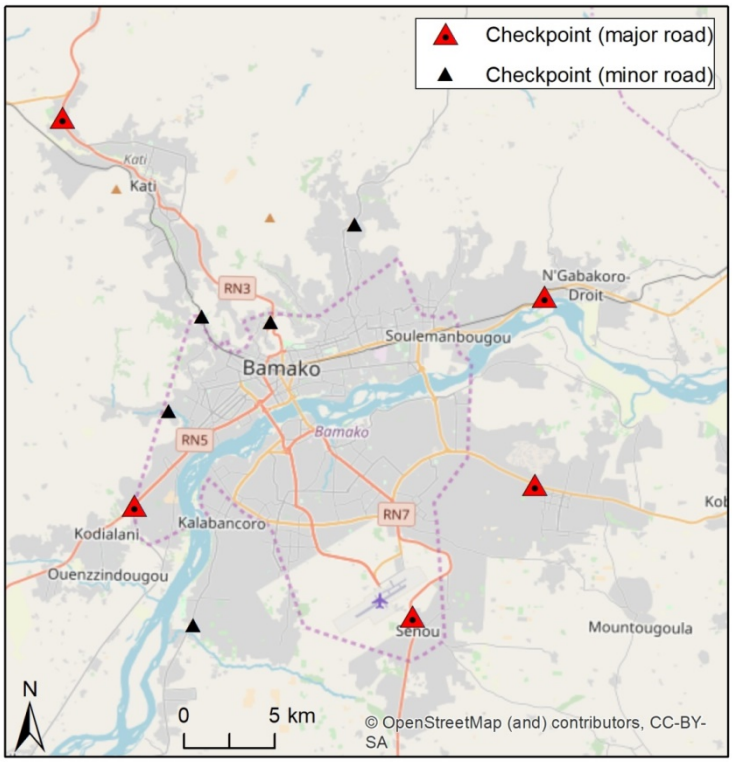


Figure 1. Data collection points on major and minor access roads leading to the city of Bamako, Mali. Due to the diversion of the road leading from Kati to Bamako, data were collected at two other check points. Data duplicates were removed before analysis.

Mali's hot season stretches from March to June, and is characterised by monthly average temperatures of up to 37 °C and negligible precipitation [25], making it a critical period for food security due to its associated water scarcity which severely restricts crop and animal production. The rainy season begins in June/July and lasts until October/November with an average daily high temperature of 32 °C and about 260 mm of rainfall [25]. This period is suitable for the cultivation of crops for food and is characterised by the availability of grazing areas and adequate water supply for livestock. Finally, the harvest season which lasts from November to around January is characterised by widespread food availability for humans and of southern pasture and crop residues for livestock.

In each season, incoming and outgoing livestock and feed flows were recorded during one week per season for 24 h on major roads and 12 h per day (daytime only) on minor roads. Enumerators were trained to take records using a standardised survey form, including date/time, vehicle type, and identification number as well as specific information on type and quantity of incoming and outgoing cattle, sheep and goats, as well as livestock feed, geographical source, and destination of livestock and livestock feed. For the latter, highly processed livestock feed such as concentrates, and salt licks were excluded. Livestock numbers were estimated based on the information provided by drivers and from the enumerator's visual inspection (Table 1). Due to the size variability of units (transported mainly in bundles) used in livestock feed collection, it was not possible to estimate the

quantity in terms of weight of livestock feed flows and for this reason a measure of frequency was used.

Table 1. Transportation mode, livestock type and its capacity in livestock movements of Bamako (Mali) from 11/2015 to 8/2017.

Transportation Mode	Livestock	Capacity
Articulated truck	Cattle	40
Truck	Cattle	20
Pick-up truck	Cattle	1
Taxi	Cattle	1
Tricycle van	Cattle	1
Articulated truck	Sheep	200
Truck	Sheep/Goat	150
Pick-up truck	Sheep/Goat	10
Commercial bus	Sheep/Goat	50
Commercial bus (roof)	Sheep/Goat	15
Tricycle van	Sheep/Goat	10

Two enumerators were responsible for each road, with one on either side of the traffic. The point of data collection was at an official checkpoint on each of the major roads and three of the minor roads; in the case of the remaining minor road the data collection was at a strategically located point where vehicles would stop or slow down. At the official check points of the police, the gendarmerie, the water and forestry commission, the phytosanitary commission and the veterinary service, vehicles must stop for document inspection or payment of fees. This short stop offered enumerators the possibility to acquire information from the drivers about their cargo. We considered bicycles, tricycles, motorbikes, private and commercial cars including trucks, tractors, (mini-)buses, and trucks as modes of transportation. Surveys were conducted in the harvest season from 16.–22.11.2015, hot season from 02.–09.05.2016 and rainy season from 25.–31.08.2017.

2.2.2. Data Processing and Analysis

Data were entered into a PostgreSQL database, thereby linking geographical sources and destinations to georeferenced locations. When the precise number of animals was not recorded, processing included assigning a specific livestock count to each of the transportation units based on field research and expert knowledge. After cleaning and processing the data, records were grouped into:

1. Incoming flows (livestock and livestock feed coming from outside the city into the city),
2. Outgoing flows (livestock moving from within the city for a destination outside the city), and
3. Transiting flows (livestock coming from outside the city, passing through the city for a destination outside the city).

Livestock flows for each season and for each livestock were calculated to determine the scale of livestock movement. The spatial analysis used the season- and livestock-specific records with georeferenced information on source and destination. First, the main geographical source areas per season were plotted for each livestock type. Second, the incoming, outgoing, and transiting livestock flows were displayed on a map with the line thickness linking source and destination proportional to the livestock numbers. Sources of livestock feed were also plotted on a map. For these sources, we considered the number of records (counts) rather than overall quantities due to the aforementioned reasons.

Urban consumption was estimated as the difference of incoming livestock and outgoing livestock flows. Volumes of outgoing livestock flows indicated livestock trade between Bamako and other destinations, and thus, the city's role as a trade hub.

2.2.3. Limitations of the Study

The study relied on information provided by vehicle drivers or their assistants. When respondents were reluctant to provide the required information or when vehicles did not stop, we were unable to obtain information about their destination or source location. In these cases, the number of livestock or cargo space was estimated. Across the seasons, 27%, 42%, and 34% of the recorded cattle, goats, and sheep transports, respectively, did not yield information on geographical source and destination and could therefore not be used in the spatial analysis. Additionally, we only recorded livestock movements on the road, and thus have missed livestock that was trekked and thereby bypassing the road. Uncertainties regarding the local consumption of livestock arose where livestock entered Bamako for later export, or where influxes occurred before our rather short survey periods.

3. Results & Discussion

3.1. Scale, Seasonality, and Sources of Livestock Flows

Throughout the three seasons, we recorded a daily average (±SD) of 873 ± 131 cattle, 6019 ± 1633 sheep, and 210 ± 44 goats on Bamako's roads including records without location data (detailed information in Appendix A). Of all recorded livestock, vehicle transported livestock was 98% and trekked livestock was 2%. Most cattle recorded on the roads were transported in trucks (91%), and only 9% were conveyed in other transportation vehicles like tricycle vans. Sheep were also mainly transported on trucks (57%), followed by public minibus tops (22%), and bus tops (8%). Goats were mainly transported by minibuses (56%), one third transported in trucks, and the remainder by motorbikes.

For all livestock types, the number of incoming animals exceeded the number of outgoing animals by far, underlining Bamako's role as an urban consumption hub (Figure 2a–c). The difference was particularly marked in the movement of cattle, with the incoming numbers exceeding the outgoing by up to 24 times throughout the rainy season. For the hot and harvest season, they exceeded by 14 and 19 times, respectively (Figure 2a). For sheep, we recorded 7 to 11 times more incoming than outgoing numbers (Figure 2b), and 2 to 6 times more goats were entering than leaving the city (Figure 2c).

Sheep influxes were highest, with about 8,000 animals entering the city daily in the rainy season, 1000 animals in the hot season, and 800 in the harvest season (Figure 2b). It is important to note that the actual numbers were higher, considering that 15–37% of the records did not contain data on geographical source and destination. The higher sheep influxes during the rainy season were clearly linked to the rainy season's coincidence with the Eid al Adha celebration. This religious festivity calls for the slaughtering and eating of livestock, typically a ram, by each Muslim household. Slaughtering of sheep and the consumption of mutton during religious and cultural festivals like Eid al Adha, baptisms, and weddings increase meat consumption [26], meat price, and livestock price, making them lucrative for traders [27]. Like incoming sheep, the highest number of outgoing and transiting sheep was recorded during the rainy season when more than 800 sheep left the city per day, compared to about 100 sheep in the hot and harvest season. Likewise, more than 900 sheep per day were on transit in the rainy season versus 140 in the hot and 130 in the harvest season.

In the rainy season, we recorded higher daily numbers of incoming cattle than in the other two seasons (Figure 2a). Accordingly, the cattle numbers entering the city during this season amounted to 770 animals per day, compared to 380 and 260 cattle in the hot and harvest season, respectively. Again, 3–33% of all records did not contain spatial information and cattle numbers were higher. Williams [7] and Provost [28] confirmed higher livestock numbers and market prices for livestock during the rainy season. Apart from religious festivals that stimulate livestock trade, the increased trade of cattle may also be related to the commencement of the academic year in September, when the need to pay school fees is an important factor for the sale of livestock in Africa [29]. As already indicated, the proportion of outbound cattle was small in comparison with those incoming, and so were the absolute numbers, even when including those records without spatial information:

only 13–32 cattle left the city daily, with the highest number in the rainy season. The daily number of cattle passing through the city was highest in the hot season (>200 cattle) and lowest in the rainy season (86 cattle).

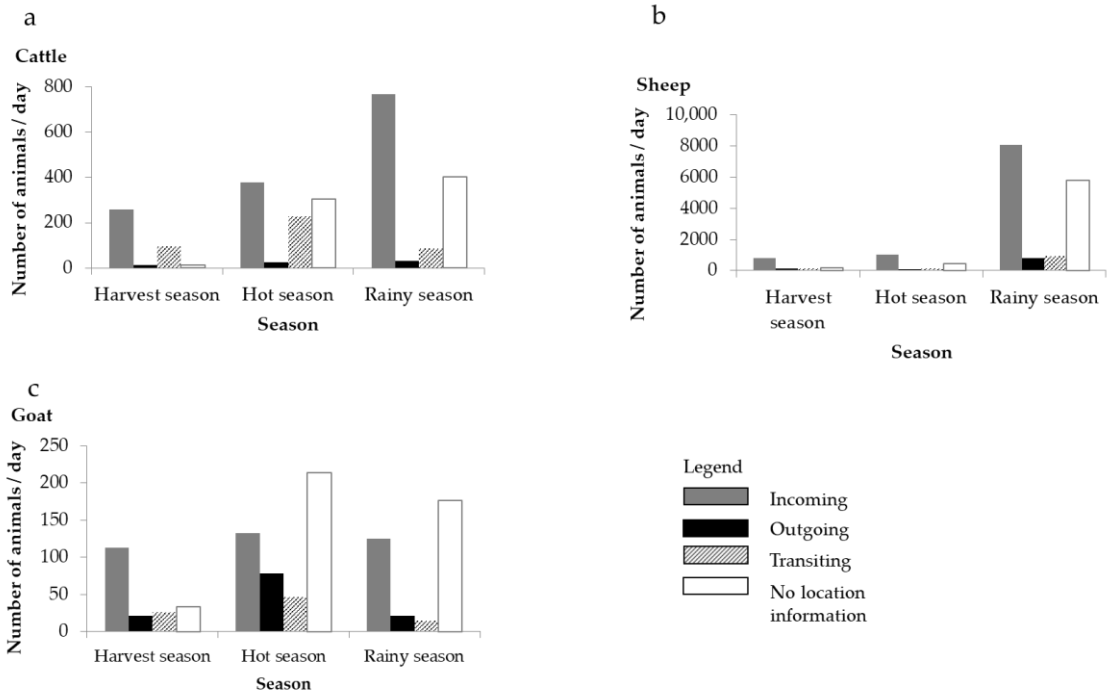


Figure 2. Daily incoming, outgoing, and transit numbers of cattle (**a**), sheep (**b**), and goat (**c**) during different seasons from 2015–2017 in Bamako, Mali.

Compared to cattle and sheep, the movement of goats played a minor role, with only slightly over 100 animals entering the city per day across the seasons (17–52% without spatial information). Possibly, goats were rather produced in private homes for consumption than imported from distant areas. The number of goats leaving the city for other destinations was similar to the number of outgoing cattle. Like cattle, the number of goats passing through the city was highest in the hot season and lowest in the rainy season (Figure 2c).

3.2. Direction of Livestock and Feed Flows

3.2.1. Incoming Livestock Flows

The main geographical sources for cattle entering Bamako throughout the three seasons were Ségou (21%) and Mopti (16%) as well as the city's surroundings within 50 km (6%; Figures 3 and 4). The southern part of the country around Sikasso was an additional source of cattle (3%) which was particularly evident in the rainy season (Figure 3). Sheep were mainly from Bamako's northern surroundings up to the Mauritanian border (23%), whereas Mopti (9%) and Ségou (4%) were less important sources for sheep entering Bamako (Figures 3 and 4). Mauritania is an important livestock producing country in West Africa and between 2015 and 2017, a cumulative total of 81 million livestock were produced by Mali and Mauritania together with the latter contributing 40% of the total headcount [30].

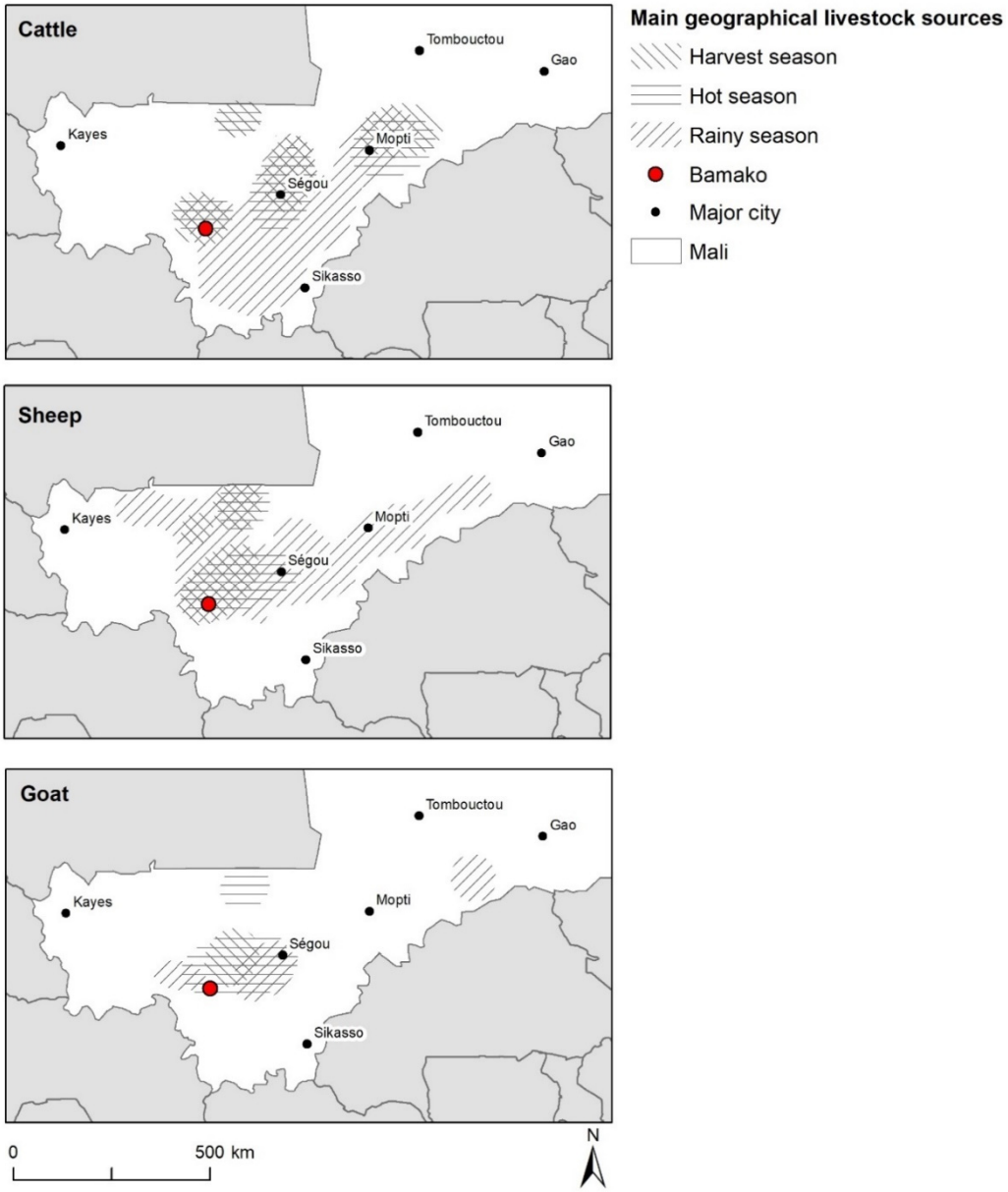


Figure 3. Geographical sources of livestock recorded in Bamako (Mali) during the hot, rainy, and harvest season of 2015–2017.

Irrespective of the season, goats did not cover large distances but came mainly from Bamako's surroundings (25%) and Ségou (13%). A plausible explanation for this could be the browsing nature of goats compared to the grazing nature of sheep [31] and the suitability of rearing goats close to the homestead. This would also explain the fewer goats recorded on the road as compared with sheep, despite the goat population in Mali for 2017 being 24 million, that is about 28% more than the population of sheep for that year [30].

The importance of Ségou, Mopti, and to a lesser extent Sikasso for livestock trade can be explained by their high number of livestock markets, allowing livestock aggregation and movement [15]. Ségou's role also reflects its major road connection to Bamako, making it a reliable trade corridor. Additionally, the city is in a region of Mali with large irrigation schemes making crop residues a readily available feed resource for livestock in an otherwise semi-arid region [32]. Mopti is a dominant source of cattle because of its large grazing areas which also make it a popular route for transhumance [33]. Large grazing areas are promoted by the hydrology of Mopti, with the presence of the Niger and the Bani rivers as well as the many connecting lakes which provide drinking water to the livestock herds

during the dry season [34]. Aside from the large grazing areas, Mopti also possesses the highest number of livestock markets (113) in the country [15], which attract 28% of Mali's marketed breeding cattle [35]. Sikasso also is an important livestock source although not as prominent as Mopti and Ségou. It is characterised by a tropical wet climate [21] which explains the cultivation of the cash crop cotton (*Gossypium hirsutum* L.; [36]) predominating livestock farming.

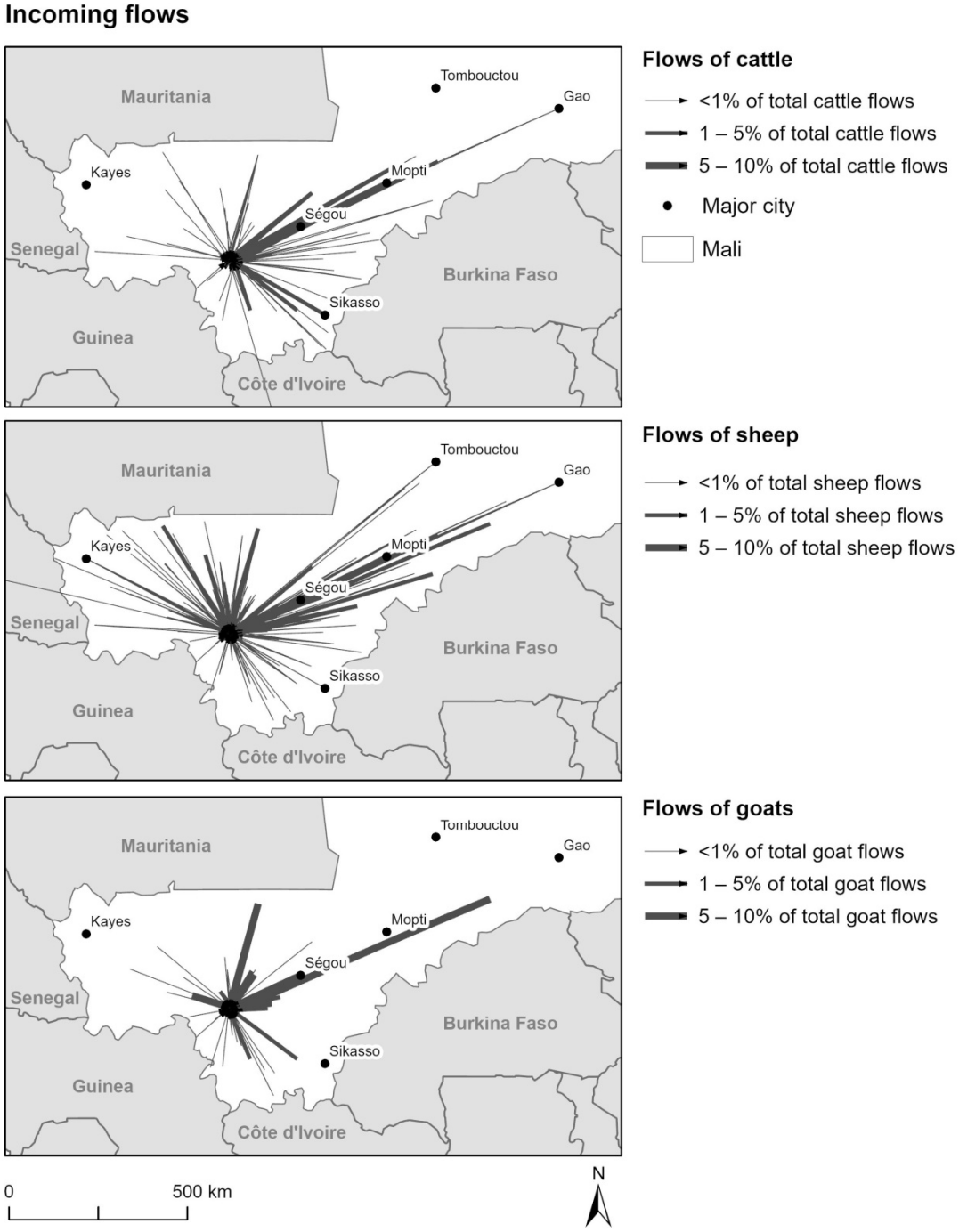


Figure 4. Flow maps of cattle, sheep, and goat into Bamako (Mali) during the hot, rainy, and harvest season of 2015–2017. The thickness of lines linking sources and destinations is proportional to the livestock volume.

3.2.2. Outgoing Livestock Flows

Cattle were leaving Bamako towards neighbouring Senegal (39% of outgoing flows) and to Kourémale (19%), one of the three livestock border markets to Guinea [37]. A large proportion of outbound sheep (39%) and goats (19%) were directly exported to Guinea (Figure 5).

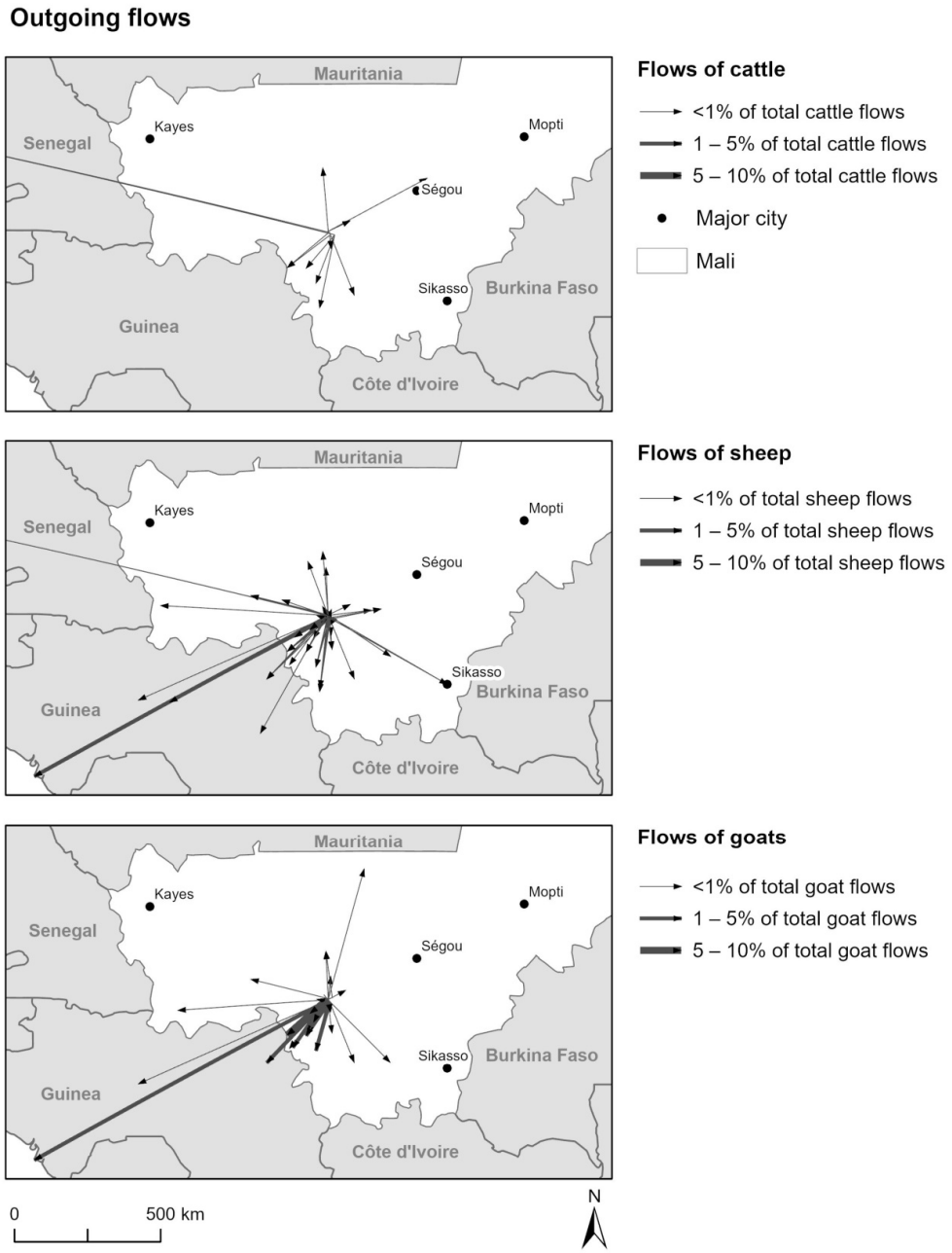


Figure 5. Flow maps of cattle, sheep, and goat leaving Bamako (Mali) during the hot, rainy, and harvest season of 2015–2017. The thickness of the lines linking sources and destinations is proportional to livestock volume.

Senegal and Guinea are major importers of livestock from Mali (Figure 5). A plausible reason for this is the dominance of Islam in both countries. As already mentioned, Islamic festivals provide a strong sink for livestock in West Africa [38]. Nevertheless, Guinea is also a transit location for livestock supply to Sierra Leone and Liberia [39] contributing to the large outflows from Mali. Additionally, Guinea's national production of

livestock, especially cattle, is plagued by parasitic disease and Africa's highest incidence of trypanosomiasis [40].

3.2.3. Transits

Bamako lies on major transport corridors connecting different parts of the country as well as neighbouring countries. Therefore, we also recorded vehicles passing through the city for other destinations. Such transits were particularly relevant for cattle, with up to 19% of the total cattle flows being transits (excluding flows without spatial information). The majority of cattle transits in Bamako were sourced from Kati Dral (43%), 25 km from Bamako's city centre, and transported mainly to Kourémale (58%) and to Senegal (11%; Figure 6). Kati Dral, a dominant livestock market, serves mainly for export and assembles cattle from other markets in the country, such as the Nioro market in the north west of the country [41].

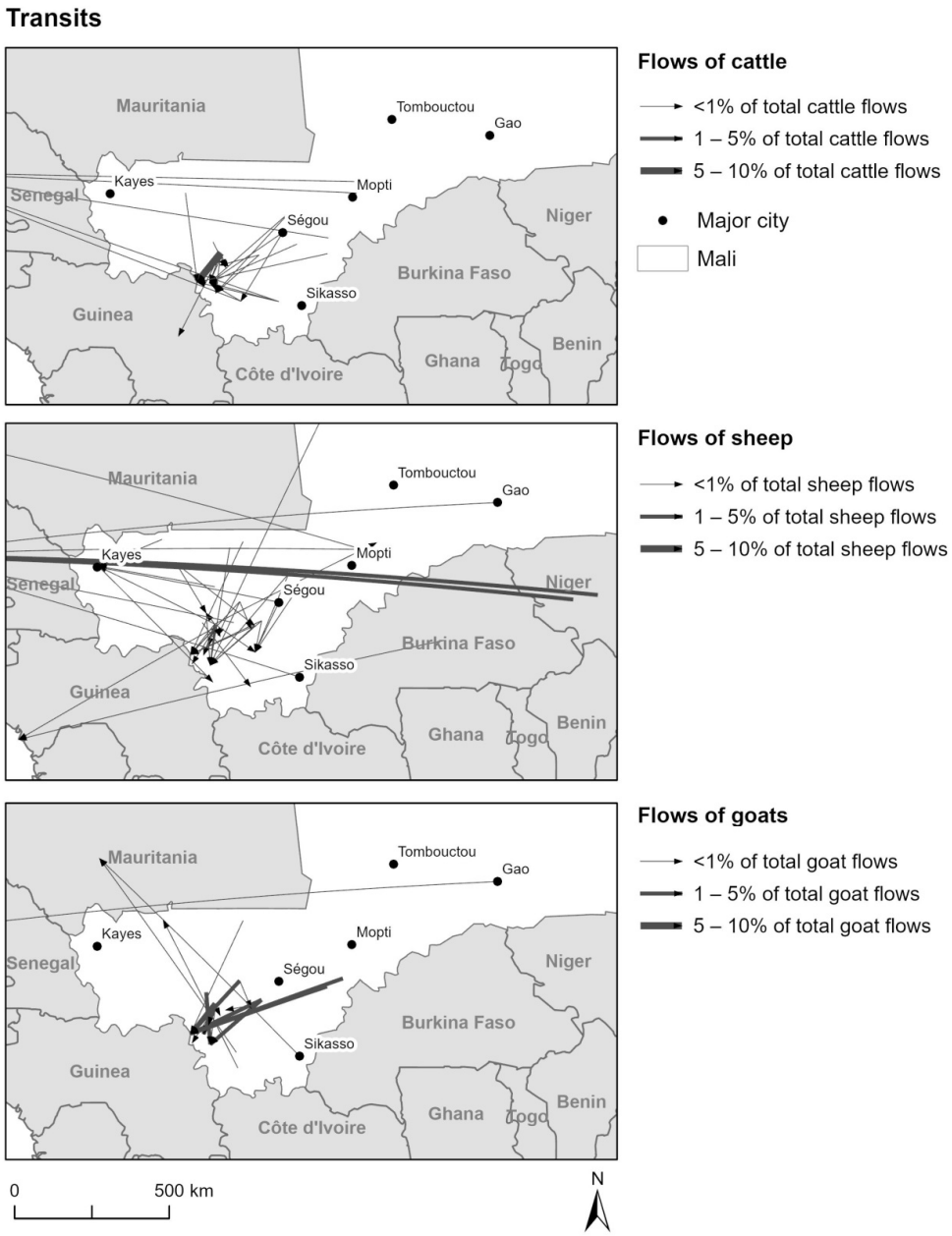


Figure 6. Flow maps of cattle, sheep, and goat transiting Bamako (Mali) during the hot, rainy, and harvest season of 2015–2017. The thickness of the lines linking sources and destinations is proportional to livestock volume.

The vehicular mobility of livestock into neighbouring countries of Mali has been facilitated by the improvement of road infrastructure. For example, livestock distribution to Senegal has benefitted from the Dakar-Bamako road and the other roads that connect to many major livestock sources within Bamako [15]. Due to the improvement of these roads, 31% of Mali's cattle for export, representing the highest national cattle export proportion, pass through Bamako to Senegal [35].

According to our data, transits of small ruminants were less important than those of cattle. The proportion of sheep flows (excluding records without spatial information) in overall transit flows was 9–12% and occurred both at a very small (city to regional) scale (<5%) and across West Africa (39% to Guinea; Figure 6). Goats accounted for 9–18% of all transit flows and moved mainly within the national borders (Figure 6). One plausible reason for this could be that cattle are considered valuable assets and are therefore more important as a store of wealth [42] than small ruminants. Another reason is that in coastal countries, where demand is high, cattle keeping is challenging, one reason being that cattle are particularly susceptible to trypanosomiasis because the tse tse fly (*Glossina* sp WIEDEMANN, 1830) vector is common in the more humid coastal areas [43]. Hence, more cattle than sheep and goats are imported to coastal countries. Lastly, small ruminants may be more easily produced on a small-scale by people, hence its lower importance for transits.

3.2.4. Incoming Feed Flows

In our study, we captured about 500 daily records of livestock feed in the rainy season, about 200 in the harvest season, and about 124 in the hot season. About 43% of the recorded livestock feed flows were transported by motorbikes, followed by minibuses (15%), motorised tricycles (14%), hand trucks (13%), bicycles (5%; Figure 7a), private vehicles (4%), pedestrians (3%), trucks and other vehicles (2%), and donkey and horse cart (1%), indicating the small scale of the business. Additionally, feedstuffs were mostly transported over short distances, hence no large vehicles are required. Livestock feed was transported heaped or in bags (Figure 7b). Our data showed that 70% of the feed sources were sourced from within a 25-km radius from the city centre (Figure 8). The major areas were southwards of Bamako along the Niger river, namely Farada, Samaya, and Tourela. These areas encompass the flooded plains along the Niger river, which have better access to water and are therefore favourable for crop farming and pasture [44] in comparison with the northern downstream section of the Niger river which is narrower, rockier, and drier with less possibility of crop farming and lower availability of pasture [45].



Figure 7. Livestock feed (**a**) transported by a motorised tricycle and a motorcycle and (**b**) in a heap at the roadside in Bamako, Mali.

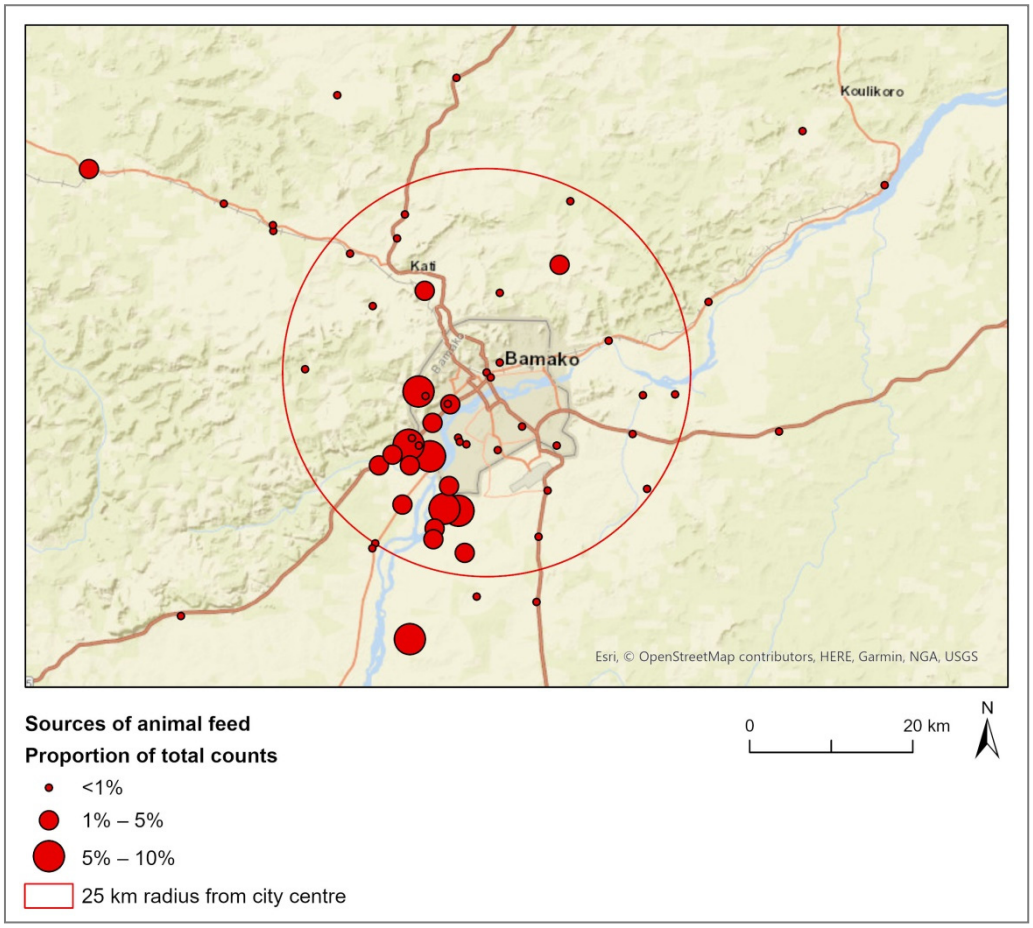


Figure 8. Locations of important sources of livestock feed in Bamako. Red bubbles represent locations and their diameter proportional to the total record count. Data were collected in the hot, rainy, and harvest season of 2015–2017.

The populations of cattle, sheep, and goats in Bamako have been estimated at 35,000, 58,000, and 36,000, respectively [35], which corresponds to a population of 33,900 ruminants of 250 kg body weight (Tropical Livestock Unit, TLU). With a yearly feed intake of 482 kg DM (dry matter) for an average sheep, 396 kg DM for a goat and 2156 kg for a cattle [46], it can be assumed that about 66,920 t of feed DM are required annually for the ruminant livestock herd in Bamako. Currently, the city loses surrounding grassland at a rate of about 2.6% per year while its urban area is expanding at 5.4% [47], mainly towards the Kabala axis, which is also one of the biggest zones of fodder production (Figure 6). Where grassland is not converted into an urban built-up area, the transport of feeds into the city will lead to nutrient depletion of the feed-supplying rural hinterlands if the nutrients are not returned in the form of livestock manure [46].

3.3. Future Perspective

Bamako, with a population of about 2.6 million (2020), will keep expanding to absorb its increasing population, projected to increase by 50% by 2030 [47,48]. This will increase the demand for food and in particular livestock products [49], given that the per capita meat consumption of urban dwellers is also increasing as the middle class grows in Sub-Saharan Africa [20]. In 2013, meat consumption in Mali reached an annual per capita consumption of 18.6 kg/capita [30] which was three times as high as in other parts of West Africa. However, it was still far below North America's 36.1 kg/capita for that same year [30].

Increased livestock demand provides an economic opportunity for actors along the livestock supply chain. However, livestock infrastructure like marketing, processing, slaughtering, and veterinary services infrastructure in Bamako is inadequate [2]. This is partly because the organization of livestock institutions has been difficult, and modern livestock infrastructure like slaughter houses and milk dairies require uninterrupted electricity supply for efficient operation, despite major improvements in electricity coverage and reliability in recent years [50]. A more productive future may require increasing private investments in the sector [51], including for the efficient and reliable post-processing of livestock products.

Mali's road transport of livestock is also affected by the country's poor road infrastructure and political instability. The increased number of road checkpoints in response to the threat of terrorism in Mali slows down livestock transportation, meaning that livestock will spend longer time on the road, which may affect animal welfare, animal mortality, and animal price. Taking into consideration that only 16% of rural areas have access to roads [52], it is obvious that this situation bottlenecks vehicular livestock transportation. Herders will have to trek their animals to the next livestock "assembly" market from where livestock can be further transported on the road. The poor road network may also affect important livestock sources in the northern areas of Mopti, Timbuktu, and Gao, which means that herders will have to trek their livestock if they want to get to Bamako for better prices [15]. This trekking also implies that livestock herders will have more contact with farmers along the grazing corridor to Bamako which may trigger conflicts between herders and farmers [53].

4. Conclusions

Our study showed that livestock inflows exceeded the outflows by far for cattle, and to a smaller extent for small ruminants, underlining the city's role as a consumption centre. Bamako also acts as a major transit hub for cattle, connecting the major cattle markets nationwide, and linking the country to Senegal and Guinea. Sheep, on the other hand, are rather kept in urban livestock markets before being exported. The flows of goats are small, both in terms of quantity and distance covered, possibly due to the spatial concentration of production and consumption within Bamako and its periphery. Our study revealed the importance of religious festivals for livestock trade, reflected in a substantially higher influx of sheep compared to other seasons.

Author Contributions: Conceptualization, L.A., H.K., E.K.A.-D. and A.B.; methodology, L.A., H.K., E.K.A.-D. and A.B.; validation, A.B., H.K.; formal analysis, L.A. and H.K.; investigation, L.A., H.K. and E.K.A.-D.; resources, A.B.; data curation, L.A., H.K., and E.K.A.-D.; writing—original draft preparation, L.A., H.K., R.R., J.P., S.S.; writing—review and editing, A.B., L.A., H.K., R.R., E.K.A.-D., J.P.; visualization, L.A. and H.K.; supervision, A.B.; project administration, A.B., H.K., E.K.A.-D.; funding acquisition, A.B. All authors have read and agreed to the published version of the manuscript.

Funding: This study was funded by the German Federal Ministry of Education and Research (BMBF) and the German Federal Ministry for Economic Cooperation and Development (BMZ) within the framework of the UrbanFood^{Plus} project (www.urbanfoodplus.org) as part of the GlobE initiative (BMBF, FKZ 031A242A).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within the article.

Acknowledgments: We would like to thank Hamidou Nantoumé of *l'Institut d'Économie Rurale* (IER), and Moussa Sissoko of Point Sud for their cooperation. We also thank our enumerators for their dedication and Billa Samuel Fru for supporting the first survey. The support of *Police Nationale du Mali*, *Instituant le Controle Phytosanitaire en Republique du Mali* and *Direction Nationale Eaux et Forêts du Mali* is greatly appreciated.

Conflicts of Interest: The authors declare no conflict of interest. The sponsors had no role in the design, execution, interpretation, or writing of the study.

Appendix A

Table A1. Livestock flows (in numbers per day) in Bamako (Mali) in the hot, rainy, and harvest season of 2015–2017.

		Number			%		
Livestock	**Direction**	**Hot**	**Harvest**	**Rainy**	**Lean**	**Peak**	**Rainy**
Cattle	Incoming	377	259	768	40	68	60
	Outgoing	26	13	32	3	3	2
	Transits	228	97	86	24	25	7
	No location information	306	13	403	33	3	31
	Total	937	382	1288	100	100	100
Sheep	Incoming	1038	786	8072	61	65	52
	Outgoing	90	114	816	5	9	5
	Transits	140	130	918	8	11	6
	No location information	445	181	5785	26	15	37
	Total	1713	1211	15,590	100	100	100
Goat	Incoming	133	113	125	28	58	37
	Outgoing	78	22	22	17	11	6
	Transits	47	26	15	10	13	5
	No location information	214	33	177	45	17	52
	Total	472	194	338	100	100	100

References

1. Waha, K.; van Wijk, M.T.; Fritz, S.; See, L.; Thornton, P.K.; Wichern, J.; Herrero, M. Agricultural diversification as an important strategy for achieving food security in Africa. *Glob Chang. Biol.* **2018**, *24*, 3390–3400. [CrossRef] [PubMed]
2. SWAC-OECD/ECOWAS. *Livestock and Regional Market in the Sahel and West Africa. Potentials and Challenges*; Study Carried Out within ECOWAS Commission and SWAC/OECD; SWAC-OECD/ECOWAS: Paris, France, 2008.
3. World Bank. *Poverty and Shared Prosperity 2018: Piecing together the Poverty Puzzle*; World Bank: Washington, DC, USA, 2018.
4. Van der Lee, J.; Schiere, J.B.; Bosma, R.H.; de Olde, E.; Bol, S.; Cornelissen, J.M. *Aid and Trade for Livestock Development and Food Security in West Africa*; Wageningen UR Livestock Research: Wageningen, The Netherlands, 2014.
5. Haan, C.d.; Robinson, T.; Conchedda, G.; Ericksen, P.; Said, M.; Robinson, L.; Flintan, F.; Shaw, A.; Kifugo, S.; Wane, A. Livestock production systems: Seizing the opportunities for pastoralists and agro-pastoralists. In *Confronting Drought in Africa's Drylands: Opportunities for Enhancing Resilience*; World Bank: Washington, DC, USA, 2016. [CrossRef]
6. Cook, R. *Implementation of the Trade Hub Livestock Value Chain Program for the Mali-Cote d'Ivoire Export Corridor*; Trade Hub and African Partners Network by Abt Associates Inc.: Bethesda, MD, USA, 2015; Available online: https://docplayer.fr/3478865-Trade-hub-and-african-partners-network-implementation-of-the-trade-hub-livestock-value-chain-program-for-the-mali-cote-d-ivoire-export-corridor.html (accessed on 22 August 2019).
7. Williams, T.O.; Spycher, B.; Okike, I. *Improving Livestock Marketing and Intra-Regional Trade in West Africa: Determining Appropriate Economic Incentives and Policy Framework*; ILRI (International Livestock Research Institute): Nairobi, Kenya, 2006; ISBN 9291461873.
8. Torres, C.; van Seters, J.; Karaki, K.; Kpadonou, R. *An Exploratory Analysis of Measures to Make Trade Facilitation Work for Inclusive Regional Agro-Food Value Chains in West Africa*; ECDPM Discussion Paper 214; ECDPM: Maastricht, The Netherlands, 2017.
9. Wane, A.; Fall, A.; Keïta, F. Situation Analysis of the National Livestock Market Information System (LMIS) for Mali 2016. Available online: https://agritrop.cirad.fr/584480/1/Situation%20analysis%20of%20the%20national%20Livestock%20Market%20Information%20System.pdf (accessed on 24 December 2020).
10. Boeke, S.; Tisseron, A. Mali's long road ahead. *RUSI J.* **2014**, *159*, 32–40. [CrossRef]
11. Moseley, W.G. The Minimalist State and Donor Landscapes: Livelihood Security in Mali during and after the 2012–2013 Coup and Rebellion. *ASR* **2017**, *60*, 37–51. [CrossRef]
12. Diallo, O.A. Ethnic clashes, jihad, and insecurity in central Mali. *Peace Rev.* **2017**, *29*, 299–306. [CrossRef]
13. Benjaminsen, T.A.; Ba, B. Farmer–herder conflicts, pastoral marginalisation and corruption: A case study from the inland Niger delta of Mali. *Geogr. J.* **2009**, *175*, 71–81. [CrossRef]

14. Ickowicz, A.; Ancey, V.; Corniaux, C.; Duteurtre, G.; Poccard-Chappuis, R.; Touré, I.; Vall, E.; Wane, A. Crop–Livestock Production Systems in the Sahel–Increasing Resilience for Adaptation to Climate Change and Preserving Food Security. *Building Resilience for Adaptation to Climate Change in the Agriculture Sector*. Available online: http://www.fao.org/3/i3084e/i3084e.pdf#page=268 (accessed on 28 January 2020).
15. Bizimana, J.-C.; Angerer, J.P.; Bessler, D.A.; Keita, F. Cattle markets integration and price discovery: The case of Mali. *J. Dev. Stud.* **2015**, *51*, 319–334. [CrossRef]
16. Roessler, R.; Mpouam, S.; Muchemwa, T.; Schlecht, E. Emerging development pathways of urban livestock production in rapidly growing West Africa cities. *Sustainability* **2016**, *8*, 1199. [CrossRef]
17. Rauch, T.; Beckmann, G.; Neubert, S.; Rettberg, S. Rural Transformation in Sub-Saharan Africa. Conceptual Study. Available online: https://edoc.hu-berlin.de/bitstream/handle/18452/18666/01-en.pdf?sequence=1&isAllowed=y (accessed on 28 January 2020).
18. Yaro, J.A. Migration in West Africa: Patterns, Issues and Challenges. Available online: https://www.researchgate.net/profile/Joseph_Yaro/publication/242096940_Migration_in_West_Africa_Patterns_Issues_and_Challenges/links/5568a1fb08aefcb861d5c3b4.pdf (accessed on 29 January 2020).
19. Crump, L.; Mauti, S.; Traoré, A.; Shaw, A.; Hattendorf, J.; Zinsstag, J. The contribution of livestock to urban resilience: The case of Bamako, Mali. *Trop. Anim. Health Prod.* **2019**, *51*, 7–16. [CrossRef]
20. Desiere, S.; Hung, Y.; Verbeke, W.; D'Haese, M. Assessing current and future meat and fish consumption in Sub-Sahara Africa: Learnings from FAO Food Balance Sheets and LSMS household survey data. *Glob. Food Secur.* **2018**, *16*, 116–126. [CrossRef]
21. Beck, H.E.; Zimmermann, N.E.; McVicar, T.R.; Vergopolan, N.; Berg, A.; Wood, E.F. Present and future Köppen-Geiger climate classification maps at 1-km resolution. *Sci. Data* **2018**, *5*, 180214. [CrossRef]
22. World Weather Information Service—Bamako. Available online: https://worldweather.wmo.int/en/city.html?cityId=129 (accessed on 23 August 2019).
23. United Nations, Department of Economic and Social Affairs, Population Division. *World Population Prospects 2019: Data Booklet (ST/ESA/SER.A/424)*; United Nations: New York, NY, USA, 2019; ISBN 978-92-1-148317-8.
24. CIA. The World Factbook. Available online: https://www.cia.gov/library/publications/the-world-factbook/geos/ml.html (accessed on 10 February 2020).
25. Weather Spark. Average Weather in Bamako Mali. Available online: https://weatherspark.com/y/32134/Average-Weather-in-Bamako-Mali-Year-Round (accessed on 10 February 2020).
26. Nicolas, G.; Apolloni, A.; Coste, C.; Wint, G.R.W.; Lancelot, R.; Gilbert, M. Predictive gravity models of livestock mobility in Mauritania: The effects of supply, demand and cultural factors. *PLoS ONE* **2018**, *13*, e0199547. [CrossRef] [PubMed]
27. Gerber, P.; Mooney, H.A.; Dijkman, J.; Tarawali, S.; de Haan, C. *Livestock in a Changing Landscape, Volume 2: Experiences and Regional Perspectives*; Island Press: Washington, DC, USA, 2010; ISBN 9781597269278.
28. Provost, J. Market Participation of Livestock Owners in Bamako, Mali. Master's Thesis, Georg-August-University, Göttingen, Germany, 2016.
29. Maass, B.L.; Musale, D.K.; Chiuri, W.L.; Gassner, A.; Peters, M. Challenges and opportunities for smallholder livestock production in post-conflict South Kivu, eastern DR Congo. *Trop. Anim. Health Prod.* **2012**, *44*, 1221–1232. [CrossRef] [PubMed]
30. FAO. FAOstat (2013): Food Supply Quantity (kg/capita/yr) for Item Codes 2731, 2732, 2733. 2019. Available online: http://www.fao.org/faostat/en/#search/Meat%20%2B%20Total (accessed on 15 November 2020).
31. Isaakidou, V.; Styring, A.; Halstead, P.; Nitsch, E.; Stroud, E.; Le Roux, P.; Lee-Thorp, J.; Bogaard, A. From texts to teeth: A multi-isotope study of sheep and goat herding practices in the Late Bronze Age ('Mycenaean') polity of Knossos, Crete. *J. Archaeol. Sci. Rep.* **2019**, *23*, 36–56. [CrossRef]
32. Gautier, D.; Locatelli, B.; Corniaux, C.; Alary, V. Global changes, livestock and vulnerability: The social construction of markets as an adaptive strategy. *Geogr. J.* **2016**, *182*, 153–164. [CrossRef]
33. Brottem, L.V. Environmental change and farmer-herder conflict in agro-pastoral West Africa. *Hum. Ecol.* **2016**, *44*, 547–563. [CrossRef]
34. Dayamba, D.S.; Ky-Dembele, C.; Bayala, J.; Dorward, P.; Clarkson, G.; Sanogo, D.; Diop Mamadou, L.; Traoré, I.; Diakité, A.; Nenkam, A.; et al. Assessment of the use of Participatory Integrated Climate Services for Agriculture (PICSA) approach by farmers to manage climate risk in Mali and Senegal. *Clim. Serv.* **2018**, *12*, 27–35. [CrossRef]
35. DNPIA. Direction Nationale Des. Productions et des Industries Animales. Rapport Annuel 2015. 2016. Available online: http://www.ofarcy.net/elevage-mali/docs/84-RAPPORT_ANNUEL_DNPIA_2015_docx.pdf (accessed on 23 August 2019).
36. Cooper, M.W.; West, C.T. Unraveling the Sikasso paradox: Agricultural change and malnutrition in Sikasso, Mali. *Ecol. Food Nutr.* **2017**, *56*, 101–123. [CrossRef]
37. Dione, M.M.; Traore, I.; Wieland, B.; Fall, A. *Feed the Future Mali Livestock Technology Scaling Program (FtF-MLTSP)—Participatory Assessment of Animal Health Service Delivery Systems in Mali: Constraints and Opportunities*; ILRI: Nairobi, Kenya, 2017.
38. Apolloni, A.; Nicolas, G.; Coste, C.; Mamy, A.B.E.; Yahya, B.; Arbi, A.S.E.; Gueya, M.B.; Baba, D.; Gilbert, M.; Lancelot, R. Towards the description of livestock mobility in Sahelian Africa: Some results from a survey in Mauritania. *PLoS ONE* **2018**, *13*, e0191565. [CrossRef]
39. CILSS. Commerce Transfrontalier et Sécurité Alimentaire En Afrique de l´Ouest. Cas Du Bassin Ouest: Gambie, Guinée-Bissau, Guinée, Mali, Mauritanie, Sénégal. 2010. Available online: https://documents.wfp.org/stellent/groups/public/documents/ena/wfp219290.pdf (accessed on 5 February 2020).

40. Kagbadouno, M.S.; Camara, M.; Rouamba, J.; Rayaisse, J.-B.; Traoré, I.S.; Camara, O.; Onikoyamou, M.F.; Courtin, F.; Ravel, S.; Meeûs, T.d.; et al. Epidemiology of sleeping sickness in Boffa (Guinea): Where are the trypanosomes? *PLoS Negl. Trop. Dis.* **2012**, *6*, e1949. [CrossRef]
41. Diallo, F.; Dembélé, M.; Gourichon, H. Analyse des Incitations par les Prix pour les Bovins au Mali 2005–2012. 2014. Available online: http://www.fao.org/in-action/mafap/resources/detail/es/c/396256/ (accessed on 24 December 2020).
42. Nevondo, T.T.; Chaminuka, P.; Nhundu, K.; Liebenberg, F. Economic returns from investment in beef cattle improvement research in South Africa. *Agrekon* **2019**, *58*, 113–124. [CrossRef]
43. Black, S.J.; Mansfield, J.M. Prospects for vaccination against pathogenic African trypanosomes. *Parasite Immunol.* **2016**, *38*, 735–743. [CrossRef] [PubMed]
44. Kassambara, B.; Ganji, H.; Kajisa, T. Impact of agricultural water allocation on the ecosystems in the inner Niger river Delta. *Int. J.* **2018**, *14*, 164–170. [CrossRef]
45. Ogilvie, A.; Mahé, G.; Ward, J.; Serpantié, G.; Lemoalle, J.; Morand, P.; Barbier, B.; Diop, A.T.; Caron, A.; Namarra, R. Water, agriculture and poverty in the Niger River basin. In *Water, Food and Poverty in River Basins*; Routledge: London, UK, 2013; pp. 141–169.
46. Schlecht, E.; Plagemann, J.; Mpouam, S.E.; Sanon, H.O.; Sangaré, M.; Roessler, R. Input and output of nutrients and energy in urban and peri-urban livestock holdings of Ouagadougou, Burkina Faso. *Nutr. Cycl. Agroecosyst.* **2019**, *115*, 201–230. [CrossRef]
47. Hou, H.; Estoque, R.C.; Murayama, Y. Spatiotemporal analysis of urban growth in three African capital cities: A grid-cell-based analysis using remote sensing data. *J. Afr. Earth Sci.* **2016**, *123*, 381–391. [CrossRef]
48. Macrotrends. Bamako, Mali Metro Area Population 1950–2020. 2020. Available online: https://www.macrotrends.net/cities/21818/bamako/population (accessed on 14 November 2020).
49. Delgado, C.; Rosegrant, M.; Steinfeld, H.; Ehui, S.; Courbois, C. Livestock to 2020: The next food revolution. *Outlook Agric.* **2001**, *30*, 27–29. [CrossRef]
50. Briceño-Garmendia, C.M.; Dominguez, C.; Pushak, N. *Mali's Infrastructure: A Continental Perspective*; The World Bank: New York, NY, USA, 2011.
51. Steinfeld, H.; Mooney, H.A.; Schneider, F.; Neville, L.E. *Livestock in a Changing Landscape, Volume 1: Drivers, Consequences, and Responses*; Island Press: Washington, DC, USA, 2013; ISBN 1597269263.
52. Gwilliam, K.; Foster, V.; Archondo-Callao, R.; Briceño-Garmendia, C.; Nogales, A.; Sethi, K. *The Burden of Maintenance: Roads in sub-Saharan Africa*. Background Paper, 14. 2019. Available online: http://roadsforwater.org/wp-content/uploads/2013/10/the-burden-of-maintenance_roads-in-SSA.pdf (accessed on 23 August 2019).
53. Turner, M.D.; McPeak, J.G.; Ayantunde, A. The role of livestock mobility in the livelihood strategies of rural peoples in semi-arid West Africa. *Hum. Ecol.* **2014**, *42*, 231–247. [CrossRef]