

**Crowding at Lake Chad: An Integrated Approach to Demographic and
Health Surveillance of Mobile Pastoralists and Their Animals**

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To Nane, Nikian and the always bustling Hacienda

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Table of acronyms

CPR	Common Property Resources
CSSI	Centre de Support en Santé Internationale
DAC	Development Assistance Committee
DFID	Department for International Development (United Kingdom)
FAO	Food and Agriculture Organisation
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IIED	International Institute for Environment and Development
ILC	International Lanc Coalition
IUCN	International Union for Conservation of Nature
LRVZ	Laboratoire de Recherches Vétérinaires et Zootechniques
MERA	Ministère de l'Élevage et des Ressources Animales du Tchad
mHDSS	Mobile Health and Demographic Surveillance System
MSF	Médecins Sans Frontières
ND	Newcastle Disease
NGO	Non Government Organisation
OECD	Organisation for Economic Co-operation and Development
REPIMAT	Réseau d'Epidémio- Surveillance des Maladies Animales au Tchad
SDC	Swiss Development Cooperation
Swiss TPH	Swiss Tropical and Public Health Institute
TLU	Tropical Livestock Units
UN OCHA-PCI	United Nations Office for the Coordination of Humanitarian Affairs – Pastoralist Communication Initiative
UNDP-GEF	United Nations Development Programme - Global Environment Facility
WB	The World Bank
WFP	World Food Programm
WHO	World Health Organisation
WISP	World Initiative for Sustainable Pastoralism

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II. Summary

Despite substantial contribution to the economies of their countries, mobile pastoralists are marginalised in many aspects of their daily lives. Mobility complicates their access to schooling or health and veterinary services. They increasingly face challenges concerning their right to use natural resources in the south-eastern Lake Chad area. Mobile communities compete with sedentary ones over access to land and water, as more and more people move into the area of the receding lake.

Little is known about the demography of mobile pastoralists. They are poorly represented in national censuses because the assessment of mobile populations proves difficult and costly.

The longstanding partnership and a history of transdisciplinary experience, connecting the population, authorities and researchers in the study area has led to mutual trust and has contributed to an environment open to innovative approaches. The concept of One Health (combining human and animal healthcare and using synergies) is well known and appreciated in the area.

The general objectives of the work presented here were:

- I. To assess the density of sedentary and mobile people and their animals in the study zone at different time points.
- II. To test and evaluate a small-scale demographic surveillance system for mobile pastoralists and their animals using mobile phones.
- III. To investigate a disease perceived as a priority by mobile pastoralists.

Throughout the data collection we conducted semi-structured interviews with representatives of all sampled communities to assess the livelihood priorities of the sedentary as well as the mobile population. The main concerns were access to food, animal and human healthcare, access to resources and the frequent conflicts between mobile and sedentary communities, access to education, legal restrictions and the loss of harvest caused by natural disasters. The information

from the interviews has served as a basis to more specifically define objective III and to analyse and discuss the results from the research addressing objectives I and II.

We assessed the density of people and animals using random coordinates to define sampling areas at four different time points from 2010 to 2012, at the beginning and at the end of the dry season. The approach allowed us to include the dynamics of population density between the seasons as well as between different years. Most of the human population lived in sedentary villages: 64.0 people per km² (95%CI: 20.3 - 107.8) compared to mobile communities who were represented by 5.9 people per km² (95%CI: 2.3 - 9.5) at the beginning and 17.5 people per km² (95%CI: 10.7 - 24.3) at the end of the dry season. However, these proportions were inverted when comparing the livestock. From sedentary communities, there were 21.0 cattle (95%CI: 1.3 - 40.7) and 31.6 small ruminants (95%CI: 13.1 - 50.1) per km². Mobile communities had on average during the dry season 66.1 cattle (95%CI: 41.1 - 91.2) and 102.5 (95%CI: 35.2 - 169.8) small ruminants per km².

During the dry season we calculated a number of 86.6 Tropical Livestock Units (TLU) per km², which exceeds up to five times the carrying capacities estimated for similar areas in the Sahel zone from older sources (14 – 23 TLU per km²). The high animal density and increasing farming activities, combined with fragile legal regulation of pastoralism and agriculture, causes frequent conflicts and leads to an unsatisfying situation for pastoralists as well as farmers. The participatory development and implementation of a new regulatory framework ("*Code Pastoral*") is essential for both the local mobile and sedentary populations.

During the period of this research we equipped 20 mobile pastoralist camps with mobile phones and conducted regular phone interviews with the leaders of the camps and their wives. All ethnic groups of mobile pastoralists in the study area have been included. We collected data on one herd of livestock per camp and all the households belonging to this herd. After the interviews, credit was transferred

to the participant's phone, and the amount was doubled if we could speak to the wife, which was an incentive for women to participate in the study. The data was validated with personal visits and for the herds with the calculation of a demographic model. Travel routes were also recorded and mapped. The results clearly showed the feasibility of demographic surveillance of mobile communities using mobile phones. All participants complied with the study during the entire period and made great efforts to be available for the interviews. As a consequence, we recommend scaling up to a large scale mobile health and demographic surveillance system (mHDSS).

The communities surveyed perceived fasciolosis as a major problem for their animals. Since infection with this liver fluke reduces body weight and milk production, it also has economic consequences for the families and can threaten food security. We assessed the dimension of the infection intensity during one year with the examination of all slaughtered animals in the three slaughter slabs of the veterinary zone of Grédaya. For each animal a short questionnaire was filled in. The overall prevalence was 22.7 (95%CI: 19.9 – 25.4%) including all animal species. For cattle, the prevalence was highest with 68% (95%CI 60-76%), for goats 12% (95%CI 10-16%) and for sheep 23% (95%CI 16-30%). Animals which had grazed at the shores of Lake Chad (with contact to open water) had a much greater risk of infection. The ethnic group of the owner was strongly associated with the risk of infection. Groups who traditionally herd their animals in close proximity of the lake such as Peul or Kouri had a prevalence between 95% and 100% for cattle, compared to Gorane and Kanembou people, who tend to stay in dryer areas, with 0% prevalence. The geospatial distribution showed that animals close to the lake were more likely to be infected. We have therefore concluded that Lake Chad is the sole source of infection and recommend treating animals feeding close to the lake regularly, as recommended by local veterinarians. However, access to treatment and treatment quality remain an issue of concern.

III. Résumé

Bien qu'ils contribuent substantiellement aux économies de leur pays, les pasteurs mobiles sont marginalisés dans plusieurs aspects de leur vie. Leur mobilité complique l'accès aux services sociaux comme l'éducation ou aux services sanitaires et vétérinaires. Ils sont confrontés à de plus en plus de défis pour accéder aux ressources naturelles par exemple l'eau et les pâturages de la zone sud-est du Lac Tchad. Les communautés sédentaires et mobiles rivalisent pour la distribution de l'accès à la terre et à l'eau, et en même temps, de plus en plus de personnes s'installent la zone asséchée du lac.

Nous savons peu sur la démographie des pasteurs mobiles. Ils sont rarement représentés dans les recensements nationaux à cause de la difficulté et du coût d'une enquête sur des populations mobiles.

Un long partenariat et une histoire marquée par les pratiques transdisciplinaires reliant population locale, autorités et chercheurs, a créé dans cette zone une ambiance de confiance mutuelle et d'intérêt pour les approches innovatrices. L'approche de Santé Unie (*One Health*) y est bien connue et appréciée.

Les objectifs généraux du travail présent étaient :

- I. Estimer la densité de la population sédentaire et mobile et de ses animaux dans la zone d'étude à des différents laps de temps
- II. Tester et évaluer un système de surveillance démographique de petite échelle pour les pasteurs mobiles et leurs animaux en utilisant des téléphones portables
- III. Enquêter sur une maladie perçue comme prioritaire par les pasteurs mobiles

Durant la collecte de données, des interviews semi-structurés ont été menés avec les représentants de toutes les communautés qui ont participé à l'évaluation des priorités des communautés sédentaires et aussi mobiles. Les préoccupations principales étaient l'accès à la nourriture, aux services sanitaires et vétérinaires,

l'accès aux ressources et les conflits fréquents entre les communautés mobiles et sédentaires, l'accès à l'éducation, les restrictions légales et la perte des récoltes causée par les désastres naturels. Les résultats des interviews ont servi de base pour définir plus spécifiquement l'objectif III et pour analyser et commenter les résultats de la recherche concernant les objectifs I et II.

Nous avons fait une estimation de la densité humaine et animale en utilisant des coordonnées prises au hasard pour définir les zones d'échantillon à quatre moments entre 2010 et 2012, au début et à la fin de la saison sèche. Cette approche nous a permis d'inclure les dynamiques de la densité humaine et animale selon la saison, mais aussi selon l'année. La majorité de la population vit dans les villages sédentaires : 64.0 personnes par km² (95%CI: 20.3 - 107.8) comparé à 5.9 personnes par km² (95%CI: 2.3 - 9.5) pour les communautés mobiles au début de la saison sèche et 17.5 personnes par km² (95%CI: 10.7 - 24.3) à la fin de la saison sèche. Par contre, concernant le bétail, les proportions sont inversées: dans les communautés sédentaires se trouvent 21.0 bovins (95%CI: 1.3 - 40.7) et 31.6 petits ruminants (95%CI: 13.1 - 50.1) par km². Les communautés mobiles ont en moyenne 66.1 bovins (95%CI: 41.1 - 91.2) et 102.5 (95%CI: 35.2 - 169.8) petits ruminants par km² pendant la saison sèche. Au total nous avons trouvé 86.6 Unité Tropicales de Bétail (UTB) par km², ce qui est quatre à cinq fois plus élevé que les capacités maximaux calculées pour des zones similaires au Sahel (14 à 23 UTB par km²). Cette grande densité d'animaux combinée aux maigres régulations légales concernant le pastoralisme et l'agriculture cause de fréquents conflits et une insatisfaction constante chez les pasteurs comme chez les agriculteurs. Le développement et l'implémentation participative d'un nouveau cadre de régulation (Code Pastoral) sont essentiels pour la subsistance de la population locale sédentaire et mobile.

Pendant cette la période d'étude nous avons équipé 20 campements mobiles avec des téléphones portables et nous avons mené régulièrement des interviews avec les chefs de campements et leurs femmes. Tous les groupes ethniques des pasteurs mobiles de la zone d'étude ont été inclus. Nous avons collecté des données sur un troupeau par campement et tous les ménages qui dépendaient

de ce troupeau. Après chaque interview, une certaine somme était transférée au téléphone du participant, et le montant de cette somme était doublé si nous avions pu parler avec la femme. Cela a renforcé la participation des femmes. Les données étaient ensuite vérifiées grâce à des visites sur le terrain et pour les troupeaux grâce à un système de calcul de modèle démographique. Les routes de transhumance étaient aussi enregistrées et cartographiées. Les résultats ont clairement montré la faisabilité de la surveillance démographique pour des communautés mobiles en utilisant les téléphones mobiles. Tous les participants ont collaboré à l'étude jusqu'à la fin et ont fait des grands efforts pour réaliser les interviews. En conséquence, nous recommandons d'élargir l'étude pour arriver à un système de surveillance mobile démographique de plus large échelle.

La fasciolose était un des problèmes mentionnés par les communautés concernant leurs animaux. Comme l'infection de la douve provoque une réduction du poids et aussi de la production laitière, les conséquences de la maladie sont aussi économiques et menacent la sécurité alimentaire des communautés. Nous avons enquêté sur la dimension de l'intensité de l'infection pendant une année dans les trois abattoirs de la zone vétérinaire de Grédaya. Un court questionnaire était rempli pour chaque animal. La prévalence générale pour les trois abattoirs était de 22.7% (95%CI: 19.9 – 25.4%) toutes espèces confondues. Pour les bovins, la prévalence était la plus élevée, avec 68% (95%CI 60-76%), pour les caprins 12% (95%CI 10-16%) et pour les ovins 23% (95%CI 16-30%). Les animaux qui avaient pâture à proximité du Lac Tchad (au contact de l'eau) présentaient le risque de l'infection le plus grand. Pour les propriétaires, l'appartenance à un groupe ethnique a beaucoup influé sur le risque d'infection. Les groupes qui font traditionnellement pâture leurs animaux au bord du lac comme les Peul ou les Kouri présentent une prévalence de 95% à 100% pour les bovins. Les Goranes ou Kanembou qui eux ont tendance à rester dans les zones plus sèches présentent une prévalence de 0%. La distribution géo spatiale a prouvé que les animaux venants de bassins près du lac présentaient plus de risque d'infection. C'est pour cela que nous concluons que le Lac Tchad est la seule source d'infection dans la zone et nous recommandons de traiter les

animaux qui pâturent près du lac régulièrement comme le recommande le vétérinaire local. Néanmoins, l'accès aux traitements et à la qualité du traitement reste un véritable problème.

IV. Zusammenfassung

Mobile Hirten werden in vielen Aspekten ihres Lebens marginalisiert, obwohl sie wesentlich zur Wirtschaft ihrer Länder beitragen. Die Mobilität erschwert den Zugang zu Dienstleistungen wie Schule, Menschen- oder Tiergesundheit. In der südöstlichen Tschadseezone haben die mobilen Hirten immer mehr Schwierigkeiten, ihr Recht auf den Zugang zu natürlichen Ressourcen durchzusetzen. Sesshafte und mobile Gemeinden konkurrieren um die Verteilung des Zugangs von Land und Wasser, während gleichzeitig mehr und mehr Menschen in die Gegend des sich zurückziehenden Sees ziehen.

Über die Demographie der mobilen Hirten ist wenig bekannt. Sie sind kaum repräsentiert in den nationalen Volkszählungen, da die Zählung von mobilen Populationen schwierig und teuer ist.

Eine langjährige Partnerschaft und transdisziplinäre Erfahrungen, die die Bevölkerung, Behörden und Forscher verbinden, haben zu gegenseitigem Vertrauen geführt und zu einem Umfeld beigetragen, das offen ist für innovative Ansätze. Das „*One Health*“- Konzept (die Kombination von Mensch- und Tiergesundheit und die Nutzung von Synergien) ist in der Gegend gut bekannt und wird sehr geschätzt.

Die generellen Ziele der hier präsentierten Arbeit waren:

- I. Die Dichte der sedentären und mobilen Menschen und ihrer Tiere in der Studienzone zu verschiedenen Zeitpunkten zu schätzen
- II. Ein kleinmasstäbliches demographisches Überwachungssystem für mobile Hirten mit Mobiltelefonen zu testen und zu evaluieren
- III. Eine Krankheit, die von den mobilen Hirten als Priorität wahrgenommen wird, zu untersuchen

Während der gesamten Datensammlung führten wir mit den Vertretern der Gemeinden, in welchen wir arbeiteten, semi-strukturierte Interviews durch, um die Prioritäten der Lebensumstände der sedentären wie auch der mobilen

Population zu beurteilen. Die Hauptanliegen waren Zugang zu Nahrung, Tier- und Menschengesundheit, Zugang zu Ressourcen und die häufigen Konflikte zwischen mobilen und sesshaften Gemeinden, Zugang zu Bildung, gesetzliche Vorgaben und den Verlust der Ernte durch natürliche Ereignisse. Die Informationen aus den Interviews dienten als Basis um das Ziel III spezifischer zu definieren und um die Resultate der Forschung zu den Zielen I und II zu analysieren und zu diskutieren.

Wir haben die Dichte von Menschen und Tieren zu vier Zeitpunkten zwischen 2010 und 2012 jeweils am Anfang und gegen Ende der Trockenzeit geschätzt. Um die Erhebungszonen zu definieren benutzten wir Zufallskordinaten. Dieser Ansatz erlaubte uns, die Dynamik zwischen den Jahreszeiten, aber auch zwischen den Jahren einzubeziehen. Der grösste Teil der menschlichen Bevölkerung lebte in sesshaften Dörfern: 64.0 Personen pro km² (95%CI: 20.3 - 107.8) verglichen mit mobilen Gemeinden, die nur 5.9 Personen pro km² (95%CI: 2.3 - 9.5) am Anfang und 17.5 Personen pro km² (95%CI: 10.7 - 24.3) am Ende der Trockenzeit stellten. Diese Proportionen sind jedoch umgekehrt für die Tierpopulation: Auf die sesshaften Gemeinden kommen 21.0 Rinder (95%CI: 1.3 - 40.7) und 31.6 kleine Wiederkäuer (95%CI: 13.1 - 50.1) pro km². Mobile Gemeinden stellen im Durchschnitt während der Trockenzeit 66.1 Rinder (95%CI: 41.1 - 91.2) und 102.5 (95%CI: 35.2 - 169.8) kleine Wiederkäuer pro km².

Alle Tiere zusammen ergeben während der Trockenzeit eine Belastung von 86.6 tropischen Tiereinheiten pro km², was die maximalen Tragekapazitäten, die für ähnliche Gegenden geschätzt wurden (14 – 23 Tiereinheiten) bis zu fünf Mal übertrifft. Die grosse Tierdichte kombiniert mit einem schwachen gesetzlichen Rahmen zur Regulation des Hirtentums und der Landwirtschaft verursacht häufige Konflikte und führt zu einer unbefriedigenden Situation für Hirten wie auch für Bauern. Die partizipative Entwicklung und Implementierung neuer regulierenden Rahmenbedingungen („Code Pastoral“) ist unerlässlich, um die Lebensumstände der lokalen mobilen und sesshaften Population zu verbessern.

Während der selben Zeit rüsteten wir 20 Hirtencamps mit Mobiltelefonen aus und führten regelmässige Interviews mit den Führern der Camps und ihren Frauen durch. Alle ethnischen Gruppen von Hirten der Studienzone waren involviert. Wir sammelten Daten von einer Herde pro Camp und all den Haushalten, die zu der Herde gehörten. Nach den Interviews wurde ein gewisser Betrag an Guthaben an das Telefon des Teilnehmers überwiesen, der verdoppelt wurde, falls wir persönlich mit seiner Frau sprechen konnten. Dies war ein starker Anreiz für die Teilnahme der Frauen. Die Daten wurden durch persönliche Besuche validiert, und für die Herdendaten wurde ein demographisches Modell berechnet. Die Resultate bestätigten die Durchführbarkeit eines demographischen Überwachungssystems mit Mobiltelefonen für mobile Populationen. Alle Teilnehmer hielten die Interviewtermine bis zum Schluss der Studie ein und unternahmen teilweise grosse Anstrengungen, um die Interviews zu ermöglichen. Wir empfehlen deshalb die Ausweitung des Projekts zu einem demographischen Überwachungssystem im grossen Massstab.

Die Fasciolose wurde von den Gemeinden als ein Problem für die Tiere genannt. Die Infektion mit dem Leberegel reduziert das Körpergewicht und auch die Milchproduktion, was ökonomische Konsequenzen für die Familien hat und die Nahrungssicherheit bedrohen kann. Wir untersuchten die Dimension der Infektionsintensität aller geschlachteten Tiere der drei Schlachtplätze der Veterinärzone von Grédaya. Für jedes Tier wurde ein kurzer Fragebogen ausgefüllt. Die allgemeine Prävalenz war 22.7 (95%CI: 19.9 – 25.4%) für alle Tierarten. Für Rinder war die Prävalenz am höchsten mit 68% (95%CI 60-76%), für Ziegen 12% (95%CI 10-16%) und für Schafe 23% (95%CI 16-30%). Tiere, die an den Ufern des Tschadsees gegrast hatten, zeigten ein viel höheres Infektionsrisiko. Die ethnische Gruppe des Besitzers hatte einen starken Einfluss auf das Infektionsrisiko. Gruppen, die ihre Tiere traditionell in der Nähe des offenen Wassers weiden, wie die Peul oder die Kouri hatten bei den Kühen Prävalenzen von 95 bzw. 100%, verglichen mit Gorane oder Kanembou, welche trockenere Zonen bevorzugten und Prävalenzen von 0% aufwiesen. Die geographische Verteilung zeigte, dass eine Infektion bei Tieren, die aus der

Nähe von Wasserkörpern vom Tschadsee stammten, wahrscheinlicher war. Wir schliessen daraus, dass der Tschadsee die einzige Infektionsquelle ist, und wir empfehlen eine regelmässige Behandlung der Tiere, die beim See grasen, wie es auch vom lokalen Tierarzt empfohlen wird. Der Zugang zu Medikamenten und die Medikamentenqualität sind jedoch problematisch, was die Behandlungsmöglichkeiten der Hirten einschränkt.

V. General Introduction

V.1 Background

V.1.1 Mobile pastoralism in the world and the Sahel zone

An estimated 100 - 200 million people worldwide can be considered mobile pastoralists (FAO 2003) while up to 36% of the ice-free land of the earth is estimated to be semi-arid rangeland adequate for pastoralism (Schwabe 1984). Pastoralism describes a livelihood dependent on the husbandry of livestock. The definition proposed by Swift (1988) is still often cited: "Where 50% or more of household gross revenue, the total value of marketed production plus the estimated value of subsistence production consumed within the household, comes from livestock or livestock-related activities, such as caravan trading, or where more than 15% of household food energy consumption consists of milk and milk products produced by the household" (Swift 1988)

Pastoralists can be sedentary or mobile or practise a combination of the two lifestyles. The term mobile pastoralists will be used throughout this thesis to describe pastoralists who respond with mobility to provide for their animals and families in the face of pasture and water scarcity. The herds are usually accompanied by the entire family of the pastoralist. Pastoralist communities may have a "home" village that is abandoned seasonally during dry periods, but they may also be without any fixed settlement.

In Africa, more than 80% of the total agricultural land is pastoral area (Rodriguez 2008). However, productive pastures are increasingly being transformed into farming areas (Lane 1996). Pastures in semiarid rangelands such as the Sahel zone are dependent on seasonal rainfall. The amount of rainfall determines the amount of fodder available to livestock. In the Sahel zone there is a single annual rainy season that determines pasture productivity for the whole year (Houerou & Hoste 1977; Breman & de Wit 1983). Most African pastoralists live in these fragile environments which are not suited for ranching. It has been shown that pastoralism in these areas is 2-10 times more productive than ranching

production (Scoones & Graham 1994). Pastoralist societies are diverse and subject to many debates. The interactions with their political, physical and social environment are complex and competition for pastoral resources can cause violent conflicts. In the last century during colonial and post-colonial periods, practices of land tenure and ownership have undergone profound changes which weakened the positions of mobile pastoralists and the management of common property resources (CPR) (Homewood & Randall 2009).

V.1.2 Sedentarisation processes

Many mobile pastoralist communities have transitioned to settlement in recent decades either voluntarily or involuntarily. The pressure from population growth, claim on pastoral areas by farmers and decreasing herd numbers have led to this process, in addition to increased opportunities in urban areas, famine and conflicts (Fratkin 1997). Sedentarisation processes have led to a number of positive as well as negative effects for the concerned populations (Homewood et al. 2006; Adano & Witsenburg 2008; Adebayo et al. 2008; Wurzinger et al. 2009; Homewood & Randall 2009).

It was often facilitated by the privatisation of land and the transformation from mobile pastoralism to ranching. Also, some of the Chadian pastoralist groups are increasingly shifting towards diversification with subsistence farming and non agricultural income in addition to mobile pastoralism, which leads to their sedentarisation (MERA 2008).

The process of sedentarisation was facilitated by the “tragedy of the commons” concept (Hardin 1968) leading to the privatisation of large land areas and to commercialisation of livestock production from the 1960s to the 1980s (Fratkin & Mearns 2003). However, the results were disillusioning as land degradation was not reduced nor was livestock production increased. Furthermore, the resilience for food shortages decreased (Swift 1991; Fratkin 1997). The livestock production sector of Africa was at a historical low in the 1980s, although about 1 billion USD were invested from 1970 to 1984, led by the World Bank. The major

flaw in Hardin's thesis was the assumption that communal rangeland would be unregulated and open to access by all. Subsequently, it was shown that traditional institutions could regulate the access to a specific resource quite effectively (Ostrom 2007; Fratkin 1997, Homewood & Randall 2009).

V.1.3 International efforts to improve livelihoods of mobile pastoralists

The issues concerning mobile pastoralists were recognised on an international level in recent years, which led to several initiatives working on improving the livelihoods of mobile pastoralists:

- The IIED (International Institute for Environment and Development) Reinforcement of Pastoral Civil Society Project is supporting a series of projects to contribute to the development of the policy framework which regulates their livelihood. It has developed a training programme for policy advocacy for pastoralists.
- WISP (World Initiative for Sustainable Pastoralism) is a UNDP-GEF (Global Environment Facility) Project implemented by IUCN (International Union for Conservation of Nature). It is a collaboration between international development agencies and NGOs to connect pastoralists around the world, share knowledge and support sustainable pastoral development (IUCN 2010).
- "Indigenous People and Pastoralists" is one of the global initiatives of the International Land Coalition (ILC). This global alliance of civil society and intergovernmental organisations aims to promote equitable access to and control over land for poor populations.
- The UN OCHA Pastoralist Communication Initiative (UN OCHA-PCI) was a three years project from 2006, funded by DFID with the aim to develop new approaches and knowledge to pastoral relief issues in Ethiopia, the "Horn of Africa, Africa and beyond" and to enhance communication between pastoralists, authorities UN and bilateral Agencies as well as the

- private sector. It also projects possible developments for pastoralism in the future (UN OCHA-PCI 2006; UN OCHA-PCI 2007).
- Also, the Swiss Development Cooperation (SDC) emphasises the need to strengthen political capital for pastoralists (Nori et al. 2006).

V.1.4 Pastoral resources in Chad

In Chad, before large scale oil exploitation started, pastoralists contributed 34% to the GDP (Hatfield & Davies 2006), which is a high proportion compared to the African average of less than 25% (Rodriguez 2008). In rural areas in Chad, pastoralism contributes as much as 53% to the GDP, and nationally the contribution is still as high as 18%. Chad encompasses approximately 84 million hectares of pastoral land, representing about 65% of the total land area. Furthermore, 80% of Chadian livestock are reared through diverse mobile lifestyles. Livestock keeping in semi-arid areas is considered to have the most promising potential to ensure food security in Chad. The value of milk and meat production was estimated to be 155 billion FCFA in 2002, corresponding to about 223 million USD (June 2002 exchange rate). Livestock and livestock products contribute 50% to the national export total (MERA 2008). Agriculture and pastoralism in dryland areas have also been shown to contribute to carbon sequestration (FAO 2004).

Decentralisation has not always been favourable for mobile pastoralists, as local authorities usually profit from the transfer of power. It has become increasingly difficult for mobile pastoralists to claim rights of pasture and water access by legal means as they are considered “foreigners” in most local perceptions (Wiese 2006). The conflicts between farmers and pastoralists call for a new pastoralist policy. At the time of writing, there is an intersectorial policy available in Chad, but it has yet to be implemented (Montavon et al. 2013).

V.1.5 Study area

The study area for this PhD project was located at the southeastern shore of Lake Chad to the east of the Chari River, extending about 100 km from east to west and 50 km from north to south. Lake Chad has been receding for the last 50 years from an area of about 25'000 km² to about 2'000 km² corresponding to a rate of 2.3% per year (Figure V.1) (IUCN 2008).

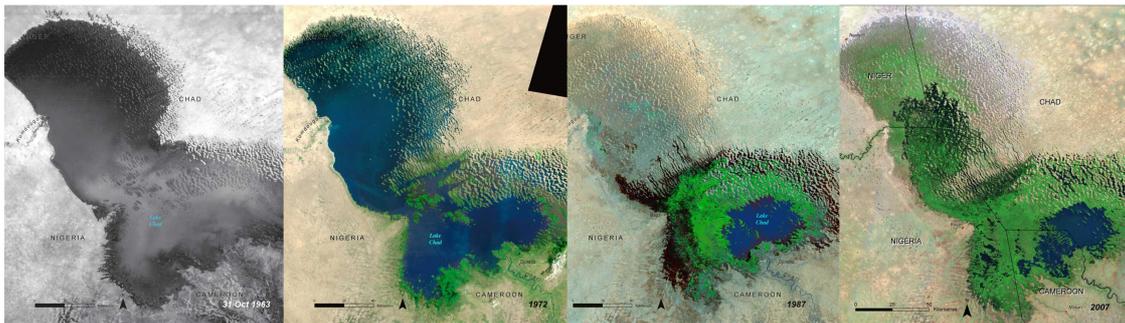


Figure V-1 Lake Chad 1963, 1972, 1987 and 2007 Source: UNEP Atlas of changing environment: <http://na.unep.net/atlas/webatlas.php?id=58>

In the study area, especially on the former lake floor, many settlements have been established during recent decades. The median age of the villages was only 29 years (25%-75% 1972 – 1990) at the time of field work which corresponded to the year 1982. The median first year of arrival in the study zone for mobile pastoralists (n=78) was 1986 (25% - 75%: 1960 – 1994) which was 25 years at the time of assessment. Responses for both groups ranged from 1 to 100 years.

In the study zone, there were mainly three groups of mobile pastoralists. A fourth group, Kouri, lived further inside the lake area on islands with a special breed of cattle (also called Kouri) endemic to Lake Chad.

The Ministry of Livestock and Animal Resources (MERA) of Chad distinguished the three groups (all with subgroups) as follows:

- Toubou groups live in the very dry areas in the north-eastern part of the country up to the border with Libya. There are many subgroups; the communities in our study zone are called “Dazagada” or “Gorane”.

- Arab people reside primarily in the central part of Chad. Fully mobile communities exist towards the north and east, but inside the study zone Arab communities are usually semi-nomadic, with a permanent village that is abandoned by at least some of the community during times of resource constraint such as the end of the dry season.
- Peul (also called Foulbé or Fulani) communities are spread over many Sahelian countries. They may also migrate across several countries, for instance from Chad to Cameroon and even including Nigeria or Central Africa. Peul consist of cattle breeding communities as well as groups specialised to small ruminant husbandry (like the “Ouda”). (MERA 2008)

For sedentary settlements, the GIS coordinates of 337 settlements in the study zone were mapped during our work, but we believe that this list is not complete. The settlements range in size from only a few huts to large villages of several thousand inhabitants. Smaller settlements are often dominated by one ethnic group.

V.1.6 Health indicators and services in Chad

The Chadian health system is struggling to provide even basic services to the population. The life expectancy is low (45 years for men and 48 years for women) and the under-5 mortality rate is 200 per 1000 live births (20%), of which 117 die while still infants. Pneumonia, malaria and diarrhoeal diseases account for 63% of the mortality of children below 5 years. In addition, maternal mortality is very high at 1100 cases of 100'000 live births and only 14% of births are attended by skilled health personnel.

Progress towards achieving the MDGs is slow and most indicators lag behind the regional average, including childhood vaccination coverage.

In 2004, there were only 345 physicians, 2387 nurses, 112 midwives and 15 dentists for the entire population of 9.7 million people (2005).

The total expenditure on health was 6.5% of the GDP. Of total general government expenditures, 10.5% was spent on health. Patients paid 96.3% of

their private health expenditures out of pocket. Per capita 51\$ (international dollar rate) were spent on health, of which 39% (20\$) were spent by the government and 61% (31\$) privately. If expressed in US\$ at the average exchange rate, the Chadian government only spent 7US\$ (2003) per capita on health (WHO 2006).

V.1.7 Development of the veterinary system in Chad

Privatisation of veterinary services occurred in the 1990s. Private veterinarians were mainly engaged in vaccination delivery targeting Rinderpest along with other diseases. After the mandatory vaccination regulations were abandoned, many of the veterinarians sought to be reintegrated into public services (MERA 2008).

Similarly, the import and distribution of veterinary supplies was privatised and is currently in the private sector. Apart from the official (private) pharmacies, a parallel unofficial sector exists in which medicines are imported and sold on an unregulated basis (Schelling 2002; MERA 2008).

The decentralised veterinary system now consists of 18 regional delegations for livestock (Délégations Régionales de l'Élevage (DRE)) which are subdivided into 56 sectors and 199 veterinary posts. Additionally, veterinary assistants are being trained by NGOs and private veterinarians.

Since 1995 there is a network for disease surveillance in place encompassing 131 of the 199 veterinary posts (Réseau d'Epidémiologie- Surveillance des Maladies Animales au Tchad (REPIMAT)). At the moment, there are 12 diseases being monitored.

However, efficient interventions are rare due to lack of funding, mismanagement and insufficient human resources, as well as poor coordination and communication. Animal diseases are pervasive and uncontrolled as is the movement of livestock within the country.

The new rural development plan attempts to address these issues by focussing on strengthening the productivity and revenues from the rural sector (improving market access) as well as on issues related to good governance (MERA 2008).

V.1.8 Health status of mobile pastoralists in the study area

A comprehensive assessment of health and morbidity in mobile pastoralists in the Lake Chad area showed that there were almost no individuals without health problems. Respiratory infections and diarrhoeal disease were diagnosed most often. Malaria was mainly prevalent in Peul communities, who remain in close proximity to the open water of Lake Chad. Conversely, malaria was rarely diagnosed in Arab communities during the dry season (Schelling 2002). The prevalence of malnutrition is an important issue in mobile communities and is subject to seasonal variation. The dietary diversity is low and high prevalences of intestinal parasites were observed among women and children.

The exposure to heat, rain and dust increases the vulnerability for certain diseases, as respiratory infections, fevers and diarrhoea (Montavon et al. 2013). Mobile communities showed higher retinol levels than those in sedentary villages due to more frequent milk consumption (Schelling 2002; Bechir 2010). However, the frequent consumption of raw milk also exposes them to the risk of infection with zoonotic diseases (Schelling et al. 2003). Although human prevalences of Q-fever and brucellosis are low, 7% of cattle were sero-positive for brucellosis and 73% of camels for Q-fever.

Mobile pastoralists know much about animal diseases and their transmission, but very little about human health issues (Münch 2012). Furthermore, they rarely visit health centres, unless they are very severely sick. Consequently, many diseases remain untreated. Ante-natal care is rarely utilised among mobile pastoralist women.

Food security is a great concern in the area, nutrition is based on milk and cereals. Cereals are bought on the market with the income from milk sales, which

depend on the availability of fodder for the animals. This leads to increased malnutrition during dry years (Bechir 2010).

The access of mobile pastoralists to health services in the area is difficult due to their mobility, but to socio-cultural reasons. Furthermore the coverage of health services in rural areas in Chad is low and not adapted to the specific needs of mobile pastoralists. They have to cover great distances to reach a health centre and are therefore absent from their herds for a long period of time. With the mobility of camps it is difficult to comply to a longer-term treatment in one health centre. Also, the communication between the centre staff and the patient from mobile communities is difficult since they speak different languages. Often mobile pastoralists have to pay more for treatment, additionally to the costs for transport, food and care for their animals in the meantime. Especially women also face difficulties as they are dependent on their husbands or other male members of the household to visit a health centre (Montavon et al. 2013).

V.1.9 Demographic surveillance and INDEPTH network

In many developing countries there is no functional demographic registration system for all citizens, and the routine Health Information Systems (HIS) are often poorly organised and unable to meet scientific demands for data. This issue is addressed by the International Network for the Demographic Evaluation of Populations and Their Health (INDEPTH), which is a global network of longitudinal health and demographic surveillance sites in low- and middle-income countries. The network aims to build capacity for Health and Demographic Surveillance Systems and research in multiple sites to develop health priorities based on scientific evidence (INDEPTH 2013).

Until now, all INDEPTH network surveillance sites cover only sedentary populations.

Previous demographic research on mobile communities was generally focussed on fertility and mortality rates (Hampshire & Randall 2000; Homewood & Randall 2009).

Population assessments have been conducted by aerial sensing (Taragi et al. 1994) or using the “waterpoint approach” (Kalsbeek 1986). Both approaches have the disadvantage of needing to be validated on the ground. In the study area, people and animals often stay underneath trees and bushes during the heat of the day, complicating aerial sensing. Furthermore, there is no complete reference list of water points, and migration or use of multiple water points have to be taken into account.

V.1.10 The use of mobile communication technology in Africa

In recent years, the fast development of information and communication technology (ICT) has opened many opportunities for African people. The increasing network coverage led to rapid, widespread adoption of mobile phone use in Africa, with the internet bandwidth availability growing 20 fold between 2008 and 2012. A large portion of communication is conducted by mobile phones, which also serve as a means for financial and trade activities. There are more than 650 million mobile phone subscribers in Africa, which is more than in the US or European Union. The market for mobile communication has grown more than 40 times from 2000 to 2011, and contributing 7% to the African GDP, which is more than the global average. Information and communication technology is already used in agriculture to improve market access and to assess conditions and can help to address climate change, natural disasters, environmental degradation and food security (The World Bank et al. 2012).

In the health sector, text messages as well as phone calls and internet services are used for telemedicine in various fields (Déglise et al. 2012; Gurman et al. 2012; Källander et al. 2013). Examples of application include control of disease outbreaks, reminders for treatment compliance, training and consulting services for health personnel, health services for patients in remote areas, stocking and ordering of medicines and vaccines and behaviour change advice and information for the population.

The mHealth Alliance (mHA), launched 2009 by the United Nations Foundation, Rockefeller Foundation and Vodafone Foundation, advocates for research, builds capacity and promotes sustainable business models for the use of mobile technologies in health.

Furthermore, the benefits of mobile technology have been shown for the veterinary sector (Madder et al. 2012) and One Health approaches (Karimuribo et al. 2012).

In Chad, the project for the promotion of telemedicine in West Africa (RAFT, Réseau en Afrique Francophone pour la Télémédecine) has been established in collaboration with the Geneva University Hospitals and is at the moment scaling up to cover new sites. It focuses on training of doctors in remote areas and facilitates tele-consultations and specialised services as tele-echography via information technology.

V.1.11 Research principles: One Health and Transdisciplinarity

Klaus Schwabe described the added value and synergies of a combined approach between human and animal health care, which he called “One Medicine” (Schwabe 1984).

Transdisciplinarity aims to assess relevant complexity of a problem, taking into account the diversity of stakeholders, to overcome the famous quote “the world has problems, but Universities have disciplines” (Hirsch Hadorn 2008, Wilson 2009)

In the 1990s, staff from a rural health centre near the Lake Chad area observed that mobile pastoralists passed their health centre without utilising the services. The local primary healthcare programme, executed by the Centre de Support en Santé Internationale (CSSI), was asked to develop more accessible services for mobile populations. CSSI, at that time a branch of the Swiss Tropical Institute (STI) in Basel, conducted a pre-study in 1996 to assess the access of mobile pastoralists to health services in Chad.

A research partnership resulted between the Laboratoire de Recherches Vétérinaires et Zootechniques de Farcha (LRVZ), CSSI, and the Ministry of Health. Diverse research disciplines were brought together, including medicine, veterinary epidemiology, social geography, anthropology and biology. The projects were complementary despite a strong disciplinary approach, and much baseline knowledge in different areas was generated, including human and animal health as well as information about zoonoses and livelihoods of mobile pastoralists (Schelling et al. 2003; Krönke 2004; Wiese 2004; Bechir et al. 2004; Diguimbaye et al. 2004; Wiese 2006). The research led to tangible results such as the rehabilitation of a non-contaminated anthrax vaccine.

Stakeholders on a national and local level were involved from the beginning in the research process. Several national stakeholder workshops were held to share results and discuss interventions and the course of action. Stakeholders included different ministries, NGOs and multi- and bilateral organisations, as well as representatives of the communities. The fourth national workshop addressed mainly policy issues like building ownership and transferring the pilot interventions into national public health policy (Schelling et al. 2008). This process then stalled for several years as collaboration between the ministries proved to be difficult and the Chadian government was unwilling to contribute to the funding of a larger scale project. Currently the development of a national approach is in preparation, but implementation proves to be difficult.

V.1.12 Joint human animal vaccination

The early research projects indicated that most livestock was adequately vaccinated, in contrast to young children, of which none had completed the childhood vaccination programme. On the basis of several workshops and discussions between the concerned population, authorities and researchers, the joint human and animal vaccination programme was developed. The existing infrastructure from mobile veterinary services was used and extended to include human vaccination services. The vaccines were provided by the National

Expanded Programme on Immunization (EPI). The programme contributed to strengthening the relationships and collaboration between veterinary and health services, and the approach built trust amongst the mobile population and veterinary and health service providers as well as researchers. The combination of services was also shown to be cost-effective as the public health sector could save 15% of its operational cost during the campaigns (Bechir et al. 2004). The evaluation of the programme on a population scale (vaccination coverage) was complex as the communities were difficult to locate again at a later time. Although 4,022 nomadic children were fully immunised, 6,284 women received at least 2 doses against tetanus and a total of 103,500 livestock were vaccinated, no vaccination coverage could be estimated as there was a lack of baseline data for the mobile population (Schelling et al. 2008).

This was addressed by Weibel who aimed to estimate the size of the mobile population in the area. He adapted the method of capture-mark-recapture as used in ecological and wildlife studies. Biometric fingerprints were used to register and identify mobile pastoralist women, and random transects were conducted as the sampling method and also for re-encounter. The approach proved to be applicable, but the number of re-encounters was too low to estimate the population size for such a highly mobile population (Weibel 2008).

V.1.13 Research partnerships

Centre de Support en Santé Internationale, N'Djamena, Chad (CSSI)
The Swiss Tropical Institute (currently the Swiss Tropical and Public Health Institute) developed its local coordination office into an independent organisation (Bureau d'Appui Santé et Environnement, BASE) in 1996 and retained a presence in Chad through CSSI, eventually managed entirely by local staff and becoming an independent NGO in 2006.

The goal of CSSI is "to contribute to the improvement of the health of populations on national and international level by means of service delivery, research and training in the context of a systemic approach" (internal document). The

multidisciplinary staff includes medical doctors, epidemiologists, geographers, nutrition specialists, nurses, midwives, administrative professionals and others. CSSI is active in several domains of health service delivery and research and is one of the leading health organisations in Chad.

This PhD was associated with the National Competence Centre for Research (NCCR) North-South, which is an instrument of the Swiss National Science Foundation (SNSF). It is jointly funded by the Swiss Agency for Development and Cooperation (SDC). The programme was founded in 2001 and will be concluded in 2013. (<http://www.north-south.unibe.ch>)

NCCR North-South is organised in geographically separated Joint Areas of Case Studies (JACS) and thematically specified research groups. The three main thematic research focusses are 1.) institutions, livelihoods, conflicts and 2.) health, services, planning and 3.) natural resources, economy and governance. This project was associated with JACS West Africa and the Research Project 10 – services for mobile populations.

Funding for the present PhD was provided by the ProDoc, a programme of the Swiss National Science Foundation which was from 2008 jointly led with the Rectors' Conference of the Swiss Universities (CRUS). It aimed to launch and reinforce high-level doctoral programmes in Switzerland.

All research was done following the KFPE Guidelines for Research in Partnership with Developing Countries (http://www.kfpe.ch/key_activities/publications/guidelines/guidelines_e.php). The research was conducted in collaboration with Chadian field and scientific staff and regular exchange was sought with Chadian scientists.

V.2 Identified research gaps

Demographic baseline data is the basis for a successful planning and implementation of health interventions. This is true for human as well as for animal health services, and can be extended to other social services.

Very little is known about demographic parameters of mobile pastoralists especially in Central- and West Africa (Homewood & Randall 2009). Regular visits for interviews for demographic surveillance as practiced by the INDEPTH-network for sedentary populations are not applicable in this context. One method available is direct observation (Münch 2012), which is costly and not applicable to a larger population. The approach of registration with biometric finger prints and transects for recapture did not work well due to low recapture rates (Weibel et al. 2008). Hence, we currently lack cost-effective and applicable methods of demographic surveillance of mobile pastoralists.

To address this lack of information and of approaches to obtain it, we aim to develop innovative methods and test them. The methods have to be low-cost and well accepted by the target population.

The longstanding research experience in the area nourished the suspicion of overuse of natural resources, which can be observed by the increase of non-palatable plant species as *Calotropis procera*. The population is aware of the issue of resource scarcity and experiences its consequences in daily life.

However, no recent estimates exist of human and livestock density in the area. The development of an applicable method is needed to quantify these numbers depending on seasonal use of pastures. With this information we aim to estimate the effective livestock density for sustainable resource use, reflecting also the needs of mobile pastoralists as well as sedentary communities.

The livelihoods of pastoralists are directly linked to their social and ecological system (Homewood & Randall 2009), which has become increasingly dynamic through changes in climate, land use (increasing agricultural use as well as land grabbing), demography (population growth, rural-urban migration) and security issues (current conflicts with extremists in the post-Arabic-spring era). Health and demographic planning can not be addressed without considering actualised perceptions on livelihood and development priorities. The current gap in this regard is an up to date understanding of perceived priorities for pastoralist livelihoods and development.

Health of people as well as of animals is a condition to a dignified life of mobile pastoralists. They depend economically but also socially on the productivity of their livestock. Research into specific health issues which are perceived as priorities by the population can help to improve health and at the same time the resilience to other livelihood problems: healthier animals produce more milk which improves the nutrition of people, or healthier children can better guard the herds and keep them from entering agricultural fields, which contributes to avoiding conflicts. There is still too little information on specific diseases (human as well as animal) to address efficiently the perceived issues of concern.

V.3 References

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VI. Objectives

- I. To assess the density of sedentary and mobile people and their animals in the study zone at different time points
 - a. To develop a method to assess human and livestock density
 - b. To estimate the density of humans and livestock in the study area
 - c. To estimate the intensity of pasture use

- II. To test and evaluate a small-scale demographic surveillance system for mobile pastoralists and their animals using mobile phones
 - a. To establish a small scale cohort for demographic surveillance
 - b. To test and evaluate demographic surveillance interviews with mobile phones
 - c. To assess the dynamics of camp composition in relation to people and animals
 - d. To obtain information on transhumance speeds, routes and schedules

- III. To investigate a disease perceived as a priority by mobile pastoralists
 - a. To assess livelihood priorities of mobile pastoralists
 - b. To evaluate the relative importance of human and animal health in relation to other livelihood issues
 - c. To investigate a perceived human or animal health problem

Chapter 1

Transdisciplinary approach to research with rural mobile and sedentary communities: expressed issues and priorities

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1.1 Abstract

The area near the shores of Lake Chad is densely populated as many communities have settled on the fertile former lake floor. However, mobile pastoralist communities of different ethnic groups live also in the area under increasingly marginalised conditions.

As part of a transdisciplinary process, semistructured interviews were conducted in 87 mobile communities and 40 sedentary villages to assess livelihood priorities and to define research needs. Responses were qualified in spontaneous and probed answers.

Access to food was the priority mentioned most often by mobile communities, followed by veterinary and human healthcare. The agricultural fields of sedentary farmers which limit access to pastures and water for mobile communities were of great concern for mobile pastoralists. Other important problems mentioned were access to water and the lack of education. Some issues concerned mainly either the sedentary or the mobile population, but others were shared between them. Several explanations were given for expressing or choosing a priority. The expressed issues are interdependent and often causally linked.

Better quality treatment and locally adapted health and veterinary services would contribute to improve the livelihoods of both, mobile and sedentary populations. Access to natural resources frequently caused commonly conflicts in the area. A new regulatory framework for pastoralists, developed in a participatory way with involvement for the local and national government as well as the sedentary and mobile population, could address the main issues.

Keywords: Transdisciplinarity, rural livelihood, mobile pastoralists, priorities

1.2 Introduction

The Handbook of Transdisciplinary Research starts with the sentence „Transdisciplinary orientations in research, education and institutions try to overcome the mismatch between knowledge production in academia and knowledge requests for solving societal problems“ (Handbook of Transdisciplinary Research, 2008). This is especially important in regions or societies in which traditional science is not well established and there is not much information available.

An overly narrow perspective on a problem can lead to unanticipated adverse effects when an intervention is introduced, as many experiences from development aid have shown (DFID 2010). Such examples led also to the development of the “Do No Harm”-principle (Anderson 1999; OECD 2010). The first of the 10 Fragile State Principles of OECD/DAC is: “Take context as starting point”, which stresses the need to understand the specific context and to “avoid blue-print approaches” (OECD/DAC 2007).

To follow a transdisciplinary approach when doing research means to involve the concerned population, authorities and other stakeholders from the planning and definition of research needs to evaluation and the implementation of interventions based on the results.

In recent years, the area at the southeastern border of Lake Chad has become a “hotspot” area, and the increasing density of sedentary and mobile communities contributes to conflicts between them. The median age of settlements was only 29 years in 2011 (n=30; 25%-75%: 1960 - 1994) and the median year of reported first arrival of mobile pastoralist communities was 1986 (n=78; 25%-75%: 1972 - 1990), representing 25 years at the time of assessment. Competition over land and water resources is fuelled by large animal numbers up to five times above estimated carrying capacities (see Chapter 2). Disease outbreaks, such as cholera or measles and malnutrition are frequent in the area (MSF 2012; Bechir et al. 2012).

Due to the long involvement of the Swiss TPH and its Chadian partners in the area, a wide knowledge of the concerned populations has been developed over the last 15 years (Schelling 2002; Fokou et al. 2004; Wiese 2006; Weibel et al. 2008; Krönke 2009; Bechir 2010; Weibel et al. 2011). After a preliminary study showed that cattle were often better vaccinated than children, a joint human-animal vaccination campaign was conducted from 2000 to 2005 (Schelling et al. 2007). This was well received by the local population and established a certain trust between researchers and the mobile population.

Beginning with the first preliminary study in 1996, a transdisciplinary process was undertaken. The first national stakeholder workshop was conducted in 1998, where priorities were defined and goals of the research and action programme were discussed. Then a period of trans- and interdisciplinary research followed, with the results shared and discussed at the second national stakeholder workshop in 1999. At the same time, the pilot-interventions were developed. During the period of the joint vaccination campaign, a third workshop took place to identify new research and development issues. During these workshops researchers and the local population as well as authorities and experts were involved.

Against this background and following the previous approach, it was especially important for us to take into account the view of local people from mobile as well as sedentary communities to identify research priorities and to further discuss these priorities with the experts and local authorities.

1.3 Methods

Population and study site:

The study area was located in southeastern Lake Chad area, from the shores of Lake Chad to about 100 km to the east. In this area, there is a great number of sedentary villages as well as mobile pastoralist communities of several ethnic groups. Mobile communities consist mainly of Peul or Gorane people, and settled communities can also be Kanembou or Kouri (besides Peul or Gorane). Semi-

nomadic Arab communities were counted as sedentary when encountered in a village, and as mobile when encountered in a camp.

We conducted an open and semistructured interview upon arrival in each mobile pastoralists' camp or village. This approach was maintained during the whole study period to assess current and general priorities and develop new, relevant research questions.

The interviews began with an open section, where the respondents were asked to describe the concerns of their livelihoods, first in general, then with more focus on people and on animals. After the first part participants were asked to choose their priorities from a predefined list (adapted from Weiss (2001)). This was included because the communities were not accustomed to being asked about their ideas by researchers or authorities. This approach led the participants to rank the importance of issues and mentioned ideas that might not have been stated before. It also helped to compare the responses between the different communities.

The interviews were usually conducted in the middle of the village and the respondents replied and discussed together as a group led by the community leader ("*Boulama*") or his deputy, which corresponds to their local tradition and lifestyle. Usually it was the village leader, his extended family members and other members of the community that were present at the time of our visit. There were generally substantially more men than women involved in the interviews, but this was also dependent on the specific habits of the community or ethnic group.

We could not influence the selection of interview partners and, therefore, it is likely that our respondents were rather influential personalities in the community.

The interviews were conducted in the language of the community (Kanembou, Fula or Goran) along with Chadian Arab with subsequent translation into French.

Some loss of information, as well as information quality has to be anticipated.

The replies of the participants were validated through follow-up inquiries and ambiguous replies were reassessed.

At a 2013 workshop in N'Djamena, where representatives of the mobile and sedentary population, local authorities, representatives of different ministries

(Ministry of Health, Ministry of Livestock, Ministry of Planning and others) took part as along with researchers, the following results were shared and opinions from different stakeholders were discussed.

1.4 Results and explanations

The results are displayed in Figure 1.1 and Table 1.1. In total, we collected data from 87 mobile and 40 sedentary communities (villages). Some of the participants were semi-nomads, if encountered in villages, they were counted as sedentary and if encountered in a camp they were counted as mobile communities.

Details and interpretation of the results are given below:

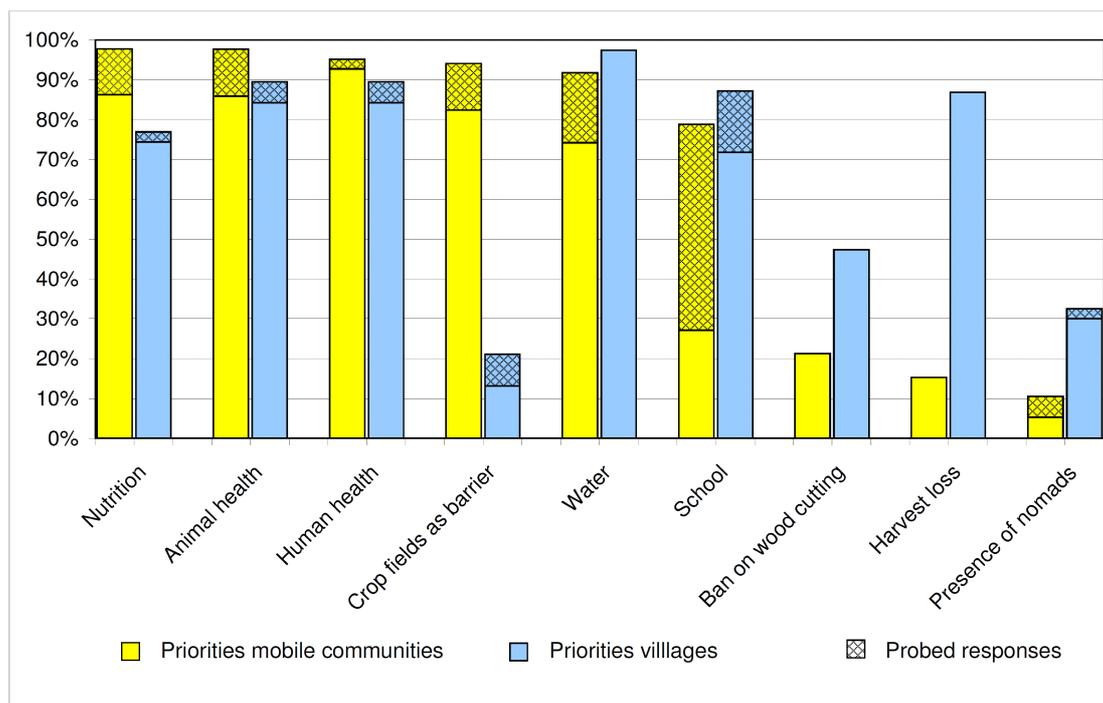


Figure 1.1: Responses from communities on their priorities. The darker columns represent the proportion of mobile communities, the lighter column of sedentary communities who mentioned the specific issue. The diamond areas represent the communities who chose the issue only as a priority after probing.

	Mobile communities							Sedentary communities						
	spontaneous		probed		not reported		total n	spontaneous		probed		not reported		total n
Nutrition	75	86%	10	11%	2	2%	87	29	74%	1	3%	9	23%	39
Animal Health	73	86%	10	12%	2	2%	85	32	84%	2	5%	4	11%	38
Human health	76	93%	2	2%	4	5%	82	32	84%	2	5%	4	11%	38
Fields as barrier	70	82%	10	12%	5	6%	85	5	13%	3	8%	30	79%	38
Water	63	74%	15	18%	7	8%	85	38	97%	0	0%	1	3%	39
School	23	27%	44	52%	18	21%	85	28	72%	6	15%	5	13%	39
Harvest loss	13	15%	0	0%	72	85%	85	33	87%	0	0%	5	13%	38
Ban on wood cutting	18	21%	0	0%	67	79%	85	18	47%	0	0%	20	53%	38
Nomads	4	5%	4	5%	68	89%	76	12	30%	1	3%	27	68%	40

Table 1.1: Number of responses from communities on their priorities, spontaneous and probed (selected priorities from a given number of choices)

Nutrition

Several aspects contribute to the problem of nutrition. First the prices for grain have increased markedly as already described in Wiese 2006, particularly compared to the price of livestock (Wiese 2006). Malnutrition has been described in the area with a prevalence in 2010 of 36% for women and 15% for children (Bechir et al. 2012) and it was associated with anaemia and parasitic infections. Given the frequent famine periods in the zone, the World Food Program (WFP 2012) and other organisations attempt to respond to the problem with the distribution of food and specialised nutrition products (MSF 2012). The mobile communities and small villages know about the distributions, but state that they don't have access to the provisions, due to corruption, perceived arbitrariness and institutional problems with aid distribution.

Another issue is loss of harvest (see paragraph "Loss of harvest") to climatic and weather incidents (droughts, flooding) as well as locusts, swarming birds or even elephants. Mobile communities also report a decrease of livestock milk production which is an important component of their nutrition.

Animal health

Apart from several parasitic and other diseases, the communities explain this problem mainly as a the lack of access to good quality treatment. Products available on the market from drug dealers is often of questionable origin and quality (Schelling 2002). The public veterinary services often do not have medicines in stock, and the only option is to take their animals to the vet stations or, rarely, pay for an expensive visit to their herds. There is a great lack of qualified veterinary personnel for several reasons (Schelling 2002), and the services are expensive.

The alternative is to buy better quality treatment in the capital N'Djamena, but this is costly and lacks the direct assessment of a qualified staff, often leading to miss-treatments.

The animals are reported to be underweight, which is another component of animal health to the communities. They explain it as the infection with parasites from the lake and also long transhumance distances and difficult, inadequate access to pastures (see paragraph "Fields").

There might be a certain bias in this answer since the communities were aware of the joint human and animal vaccination campaign conducted between 2000 and 2005, and some team members, including the local veterinarian, are well known in the area.

Human health

The institutional problems contributing to this issue are similar to those mentioned in animal health. The distance to the health centres, as well as transport and being absent from the herds, is a problem. Also, the drugs are perceived as being ineffective and expensive. Most of the children have not been vaccinated since the joint human-animal vaccination campaign which ended in 2005 (Schelling et al. 2007). Measles, whooping cough and other diseases are clearly re-emerging and are perceived as a problem again.

The prioritisation of this problem might also be biased because the communities were familiar with the collaborating organisation as well as some team members, who were trained health workers.

Fields

This point describes the increase of agricultural areas in the zone close to the lake. In recent decades, as the surface of the lake strongly decreased, many new villages have been established in the area. The farmers profit from the abundance of water and the fertility of the former lake floor. Regarding the age of the villages, the median year of foundation was 1982 (25%-50%: 1972 – 1990). Thus the average age of the settlements was only 29 years (n=30), ranging from 1 to 100 years. For mobile communities, the median year of their first arrival in the area was 1986 (25%-50%: 1960 – 1994). Thus they had regularly visited the area for 25 years (n=78) at the time of interview, with the same range of between 1 and 100 years. However, some mobile and sedentary communities had only arrived in the area during the year prior to the interview.

Mobile communities complained that the fields hindered their access to water and pastures, and if animals entered the agricultural areas they would receive egregious fines from authorities and the owners of the fields (Fokou et al. 2004; Wiese 2006).

They also stated that traditional pasture land had been converted into farmland. As expected, this point was much less raised by sedentary communities; the ones who did mention it were mostly semi-nomadic Arab groups who were also conscious of the problem from a mobile perspective.

These increasing difficulties and hostilities between mobile and sedentary communities and the role of authorities are described in more detail in a neighbouring setting on the Cameroon side of the Chari River, where many of the pastoralists interviewed in Chad also migrate (Fokou et al. 2004). According to Fokou, mobile pastoralists become more vulnerable and are perceived as virtually without rights by the sedentary population. They face discrimination and

arbitrary treatment from many sources. He is also critical of the fact that the conditions which allowed sustainable use of natural resources previously no longer apply. The more recently established formal rules allow a “free” access to pastures across borders (based on the convention of the “Commission du Bassin du Lac Tchad” in 1964), with the result that traditional local and more sustainable management systems are disabled. Nevertheless, pastoralists have to comply with regulations of local and national authorities, which exposes them to arbitrariness. Fokou warns that a lack of regard for such issues poses a risk to the survival of the concerned populations as well as the national economies (Fokou et al. 2004).

A new institutional concept for the sustainable management of pastoral resources which is adapted to local requirements and culture is urgently needed. The empowerment and participatory involvement of mobile pastoralists, together with the sedentary population, for the development of such a framework is crucial to its success.

Water

Access to clean drinking water in sufficient quantity was the main reason why sedentary communities mentioned this problem. Although almost half of the communities had access to a pump in their own or a neighbouring village, they considered the quantity or quality of the water as insufficient. For mobile communities, the problem was mainly the access to water in general and the quality of the surface water which is perceived as contaminated with disease causing organisms. This perception was confirmed by Bechir et al. who found the prevalence of intestinal protozoa to be 63% for women and 60% for children below 5 years in pastoral communities in the same area (Bechir et al. 2012). A recent study showed a high prevalence (68.5%) of the waterborne parasite *Fasciola gigantica* in slaughtered cattle (Chapter 5). Further research on schistosomiasis and fasciolosis is ongoing in the area at the moment.

None of the mobile communities had regular access to clean water. This issue was also described by Bechir et al. (2012). Periodically, they can obtain some drinking water in villages, but not a sufficient quantity for their animals. Furthermore they have increasingly problems getting permission to build traditional wells or to stay close to villages which requires exorbitant fees paid to the regional and village leaders.

Some communities also stated, usually in the second part of the interview, that they wanted to choose water from the choice of priorities because they wanted the lake to “come back” to the way it used to be many years ago, so it would flood the agricultural fields and new villages and they could have their old life back. This was envisioned as a way to “solve all the other problems”. More water in the lake with extensions as in earlier years was also considered to cause less parasitic infection risk for the people and animals.

The need for water in the Chadian Sahelian zone is expected to increase further, as for pastoralism alone, without considering agricultural needs, the estimated increase is from 174 million m³/y for the year 2010 to 234 million m³/y in 2020 (MERA 2008).

School

Mainly in the sedentary communities, a school was often named as a first priority. Ten villages had an existing school, but often it was only a community school (n=8) which means that the village population covered all of the costs. After a few years of operating a community school, the village can request that the government assumes the operational costs with a transition to an official school, but this is a difficult process dominated again by arbitrariness.

Most of the mobile communities only chose school as a priority when given the choice in the second part of the interview. None of the camps had a mobile school, some of the families sent some individual children to a school in a village or in town where they could live with members of the extended family. Although schooling was not a primary priority to them, it is remarkable that 52% (n=44) of

the communities chose it as a priority when asked to choose from a list. The mobile families explained their choice often that they considered schooling as a very important factor to contribute to the resolution of all their problems and to protect them from arbitrariness of authorities. But they also explained that they couldn't send their children to school because they were needed to care for the animals day and night to prevent the animals from entering crop fields and causing problems with sedentary communities. Bechir et al. also describe issues with mobile schooling such as compliance, financial restraints and the difficulties of a mobile life for teachers (Bechir 2010)

Ban on cutting wood

For a few years there has been a ban on cutting wood in the area. This is more and more strictly enforced through high fines, and the communities have insufficient material to construct traditional houses, corrals for the animals or traditional wells. This problem was not on the list of choices as we only became aware of it when it was named spontaneously. Therefore there is no probed proportion.

Loss of harvest

This point summarises the loss of harvest due to diverse reported natural disasters including flooding of the fields, locusts, swarming birds and elephants. As could be expected, mainly the sedentary communities perceived the loss of harvest as a priority. Although 63% (n=38) of the mobile communities reported having some crop fields in some location, it represents a minor contribution to their livelihood, and harvest is clearly not a high priority to them.

Nomads

Mostly the sedentary communities perceived the nomads as too numerous and complained that they would exhaust all the pastures around their villages so that

nothing was left for village animals. Some mobile communities on the other hand observed that people from the village would cut the dry grass and store it, only to sell it to them later for a high price.

The mobile communities very rarely chose this point; there was a great solidarity between the mobile groups. Often it was said “We are all nomads, we can deal with each other.”

1.5 Discussion

Our method is likely to have recorded the opinions of the more influential people in the community and it was not a random sample of interview partners.

Nevertheless, the issues mentioned usually concerned the entire community and not only individuals.

The transdisciplinary approach has led to further research. The animals were perceived to become infected at the lake with white worms which could be seen in the livers of slaughtered animals. With a biomedical perspective, this was interpreted as likely to be the parasite *Fasciola gigantica*, which led to further investigations. The high burden of *F. gigantica* was confirmed in a prevalence study in slaughterhouses in the area (Chapter 5). This parasite contributes to decreased milk production (Sariözkan & YalÇin 2011) which leads to a reduced cash income from milk sales and therefore less resources to buy grain for the daily needs of the mobile communities. Additionally, the need to buy grain is increased due to less milk available for direct consumption. The research on this parasite impacts several of the mentioned priorities and can be viewed as an example of transdisciplinary research. Further research continues to assess the effects of human and animal fasciolosis.

The above explanations give an idea of the complexity of the situation of the communities. None of the problems can be considered without taking into account at least some of the others. Thematically focussed projects often do not lead to the desired effect or seem unable to reach the target population, for example food aid in the area. Most of the priorities have an institutional

component in common that needs to be taken into account for the development of interventions. At the moment, authorities are perceived by mobile pastoralists as aggravating some problems, for instance access to water and rights to build traditional wells, access to pastures, access to food and conflicts with sedentary communities. The relationship between authorities and communities should be improved to allow an equitable and participatory development of the area. An adapted conceptual framework for the institutional management of natural resources and its consequent implementation as recommended by Fokou et al. is essential to reduce the burden on the livelihoods of these communities. Although the concept of “One Health”, a combined human-animal health approach, can contribute to some of the reported issues, others must be addressed on an institutional and governance level (Figure 1.2).

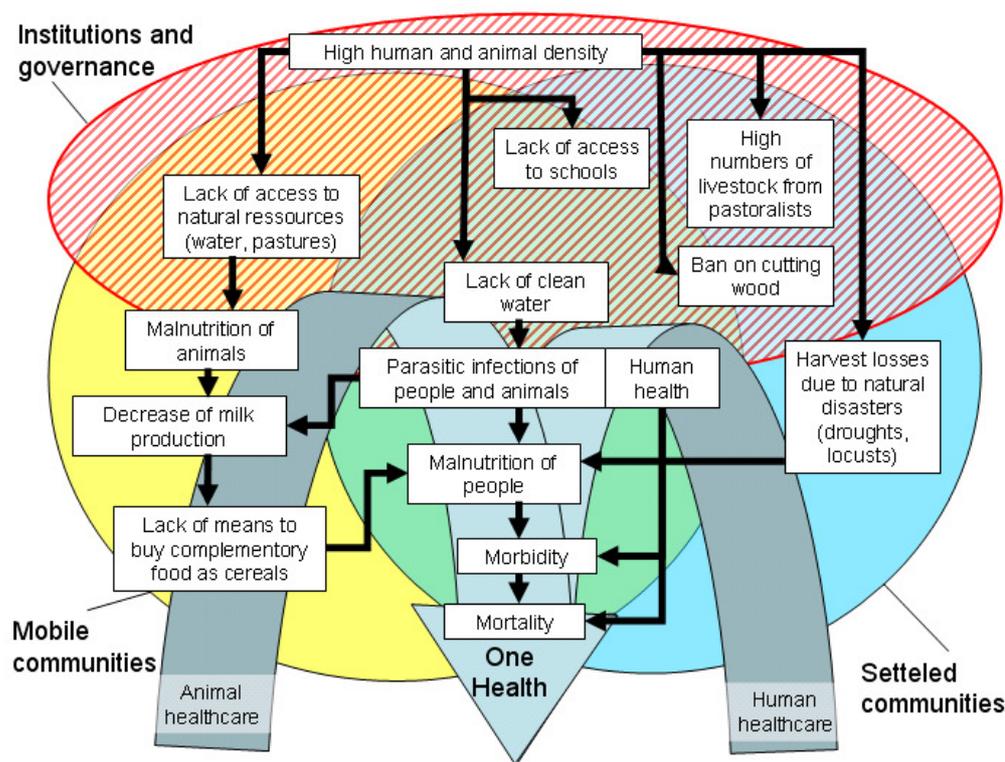


Figure 1.2: Interconnection between reported issues and field of possible interventions with the “One Health” concept as well as area of needed institutional and governance approach.

Bechir et al. call for a “minimum service package”, including human and animal health and schooling, and emphasise the need for a legal and binding framework to enable the interventions. They describe it as the condition for resource accessibility, social peace and food security. Furthermore, the strengthening of the 5 dimensions of capital have to be included in an successful development for mobile pastoralists, specifically, human capital with education and local knowledge, social capital as social and family networks, natural capital as water and pastures, physical capital as infrastructure and financial capital with market access and access to micro credits and cash (Bechir 2010; Goodwin 2003).

In March 2013, the above results were shared and discussed with representatives of the mobile pastoralist communities, authorities and service providers. In particular, the representatives of the mobile pastoralists confirmed the results from the present study and stressed the need for a new pastoral framework. Although it has been discussed for more than a decade, progress for the development of such a regulation is very slow. However, the process has gained new momentum with the involvement of new actors such as the “*Association des Jeunes Nomades*” and the FAO in recent years. Nevertheless, the collaboration remains difficult as many divergent interests are involved. During a workshop conducted in N'Djamena with the participation of mobile pastoralist camp leaders, representatives and local authorities as well as representatives from the health and veterinary sectors we discussed the results of this study and future research projects. This approach strengthened the exchange between the different parties and the platform was much appreciated by all stakeholders. The continuation of a participatory process remains central to achieving sustainable development for mobile pastoralists.

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Chapter 2

Estimating population and livestock density of mobile pastoralists and sedentary settlements in southeastern Lake Chad area, Chad

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2.1 Abstract

Although mobile pastoralists provide major contributions to the gross domestic product in Chad, little information is available on demography of mobile pastoralists and livestock. The Lake Chad area is increasingly populated by sedentary and mobile communities, resulting in competition for scarce land and water resources. For the first time, the density of people and animals from mobile and sedentary populations was assessed using randomly defined sampling areas. Four rounds of sampling were conducted in the same areas throughout two years to show the dynamics of population density. We identified 42 sedentary villages in the sampling zones as well as 11 (in 2010) and 16 (in 2011) mobile pastoralist camps at the beginning of the dry season and 34 (in 2011) and 30 (in 2012) camps at the end of the dry season. A mean of 64.0 people per km² were estimated to live in sedentary villages. In mobile communities, we found 5.9 people per km² at the beginning and 17.5 people per km² at the end of the dry season. We recorded on average 21.0 cattle and 31.6 small ruminants per km² in sedentary villages and 66.1 cattle and 102.5 small ruminants per km² in mobile communities and calculated a mean of 86.6 Tropical Livestock Units per km² during the dry season. These numbers exceed by up to five times the published carrying capacities for similar Sahelian zones. Our results underline the need for a new institutional framework. Improved land use management must equally consider the needs of mobile communities and sedentary populations.

Keywords: Mobile pastoralists, population density, livestock density, Lake Chad, random coordinates

2.2 Introduction:

Around 50 million pastoralists (Rass 2006) are estimated to live in sub-Saharan Africa. In Chad, one of the poorest countries of the world, the national census of 2009 describes about 388,000 mobile pastoralists, 3.5% of the total population (Ministère de l'Economie et du Plan, Institut National de la Statistique, des Etudes Economiques et Démographiques, 2010), while other authors estimate the number to be up to 2 million (Thornton et al. 2002; Rass 2006). Mobile pastoralist communities produce about half of the national meat production while owning about half of the country's livestock (Rass, 2006). The contribution to the gross domestic product (GDP) from livestock is recently about 18% (MERA, 2008), while before the exploitation of petrol it was thought to be near 34% (Hatfield and Davies, 2006). A published estimate suggests about 10 to 20 animals per km² on the Chadian side of Lake Chad (Thornton et al. 2002), which is low compared to recent observations. The Ministry of Livestock in Chad estimated that 8.1 million people, about 80% of the population, were living in rural areas in 2003, with at least 7 million cattle, 3 million camels and 8 million small ruminants nationwide. Of all livestock, 80% are kept in partly mobile production systems (MERA, 2008).

In the southeastern Lake Chad area, there are several ethnic groups of mobile pastoralists. The Kouri live within the lake on islands, raising a specially adapted endemic breed of cattle (Kouri cattle). In the areas accessible overland, there are three main ethnic groups. Fulani, a group spread over large areas in the Sahel zone, migrate toward the lake during the dry season, seeking green areas close to the open water. Gorane people originally come from the drier area northeast of the study zone and remain in dry areas farther from the lake throughout the dry season. Most Arab people are semi-nomadic in the study zone, living in villages and only moving to the lake when pastures around their villages are depleted near the end of the dry season (Jean-Richard *et al.*, 2014). Although smaller in number, there are also some subgroups such as Arab camel breeders, who

migrate in from regions to the north, and the Ouda (a Fulani subgroup), who raise sheep.

For mobile pastoralists, access to social services, especially health services, is very restricted. Local health care structures are not conceptualized to cover mobile populations, and there are cultural and language related access problems in addition to discrimination (Fokou *et al.*, 2004). A preliminary study on vaccination coverage showed that livestock were more fully immunized than children under the age of five years, of which none had received the full course of recommended childhood vaccinations. As a consequence a program of simultaneous vaccination of livestock and children was introduced for five years beginning in 2000 (Schelling *et al.*, 2005). To quantify the impact of this campaign on coverage, demographic information about the specific population was needed, but this proved difficult to obtain (Schelling *et al.*, 2007).

Demography of pastoral societies in general is little studied and the data is usually of poor quality. Frequently, mobile pastoralists are not included in demographic assessments (Homewood and Randall, 2009). Nevertheless, demographic information is essential for planning of social development, land management and social services, in particular health services.

Historically, demographic assessments of mobile pastoralists were mainly aimed at generating information about fertility and mortality rather than population sizes and densities, as in Hampshire and Randall (2000). Few approaches have been described to comprehensively estimate population numbers of mobile pastoralists. The “water point approach” uses data collected at wells and water bodies utilized by mobile pastoralist livestock. This approach encounters logistical issues with incomplete numbers due to use of multiple water points, variation in migration routes and the difficulty to cover all water points serving an area (Kalsbeek, 1986). Nonetheless, this method has been proposed for the livestock census yet to be conducted in Chad in collaboration with FAO (Jean-Richard, Chad, unpublished data). Aerial censuring is an alternative, but information must still be validated on the ground (MERA, 1993). The method

shows little promise in areas with many trees, where people and animals tend to rest during the daytime for protection from the sun. In the southeastern Lake Chad area, Weibel *et al.* (2008) tested an alternative method to estimate the population using random transects adapted from the capture-mark-recapture method originally developed for wildlife (Lindberg and Rexstad, 2006). Biometric fingerprints were used to uniquely identify women and children in mobile pastoralist camps. Note that identification cards are hardly ever available. Although the method proved to be feasible, the rate of recapture was too low, only about 5%, to conclusively estimate the size of such a dynamic population where communities often migrate across several countries (Weibel *et al.*, 2008). A small-scale mobile demographic surveillance system covering about 600 people was implemented from 2010 to 2012 in the study area to test the feasibility of human and animal surveillance using mobile communication technology. Mobile phone coverage had been substantially increased in the study area during the previous decade with the installation of several new antennas. The method proved to be low-cost, was well accepted by the target population and produced consistent, reliable results on life events such as births of people and livestock (Jean-Richard *et al.*, 2014). However, it was not possible to make any estimates about the number of people or animals in an area at a given point in time. In the absence of total population numbers, density estimates of people and animals can be substituted to serve as a basis for coordinating and governing sustainable use and allocation of natural resources. The aim of this study was to provide additional information about the spatial dynamics of people and animals in the southeastern Lake Chad area to better estimate the need for seasonal food aid, human and animal health interventions and schooling. Additionally, we aimed to assess the pressure of livestock in pastoral areas.

Study area

On the southeastern shore of Lake Chad, the movements of mobile pastoralists follow an annual cycle. During the rainy season, mobile pastoralists move away from the lake, returning only after the rains have ceased and the pastures are no longer flooded. Towards the end of the dry season, the pastoralists are forced due to scarce pasture to move very close to the lake where there is vegetation throughout the year on account of water availability. Figure 2.1 shows the Normalized Difference Vegetation Index (NDVI) derived from two Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images captured in November 2010 at the beginning of the dry season (A) and in April 2011 at the end of the dry season (B). The NDVI, which is a measure of photosynthetic green vegetation, calculated for April, the end of the dry season, was used to derive the area covered with water as well as the permanent green area in the study zone. In April 2011, the total area was 4983 km², with an area of 173 km² covered with water and an area of 493 km² comprised of green vegetation. Thus, 4317 km² (87%) were areas without green vegetation at the end of the dry season, reflective of rangeland with only one vegetation growth period per year during the rainy season.

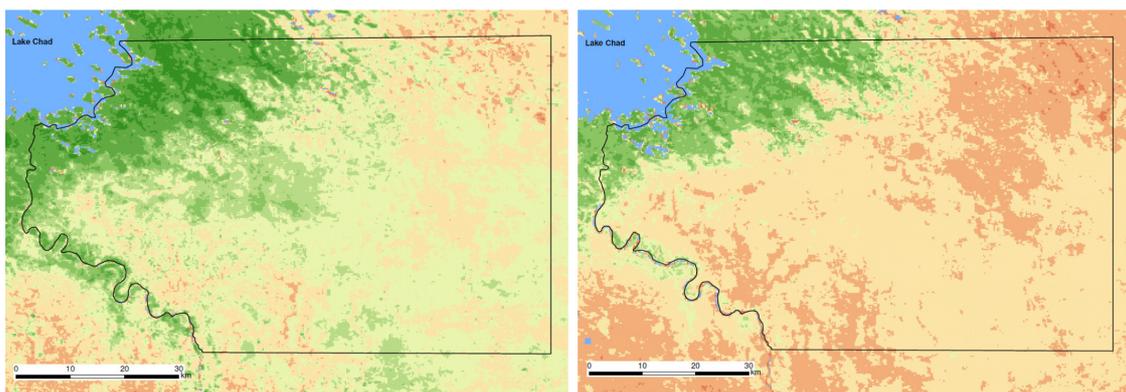


Figure 2.1: Study zone with green areas at the beginning and at the end of the dry season (November 2011 and April 2012). Pictures: CDE Centre of Development and Environment, University of Bern

Lake Chad has been receding in size for about 50 years. The open water surface was reduced from about 25,000 km² in the 1960s to about 2,000 km² in 2000 with an annual reduction rate of 2.3% of lake area (IUCN International Union for Conservation of Nature, 2008). The area of the former lake floor is very fertile agricultural and pastoral land, which has attracted the settlement of many sedentary communities of subsistence farmers. In close proximity to the open water, there are also some fishing communities. During the drought period in 1984, 12,000 people from drier areas were internally displaced to the Lake Chad area, and some subsequently remained in the zone (SECADEV, 1984; Planel, 1996; Bechir, 2012).

The settlements with the associated agricultural areas have led to increasing difficulties for mobile pastoralists to access water and pastures and also have increasingly provoked conflicts between sedentary and mobile communities. During open and semi-structured interviews, 82% of mobile communities spontaneously reported that the high number of agricultural fields were a major problem for their livelihood. In contrast, 30% of sedentary communities mentioned the high number of mobile pastoralists as a major issue. They explained that the animals of pastoralists deplete the pastures around the villages, leaving insufficient feed for village-owned livestock (Jean-Richard, 2013).

The problem of increased land use has intensified over the last 30 years: The median year reported for the foundation of permanent settlements was 1982. Similarly, mobile communities indicated their first arrival as 1986 (median), which translates to 25 years at the time of interview for this study. However, some mobile and some sedentary communities were established as recently as the previous year (see Chapter 1). Figure 2.2 shows the high number of permanent settlements in the study area, as observed in 2011. It should be noted that the number of mapped villages is likely to be incomplete since our recording was not systematic, but rather from local knowledge augmented by review of Google Earth maps, and new settlements continue to be established each year.

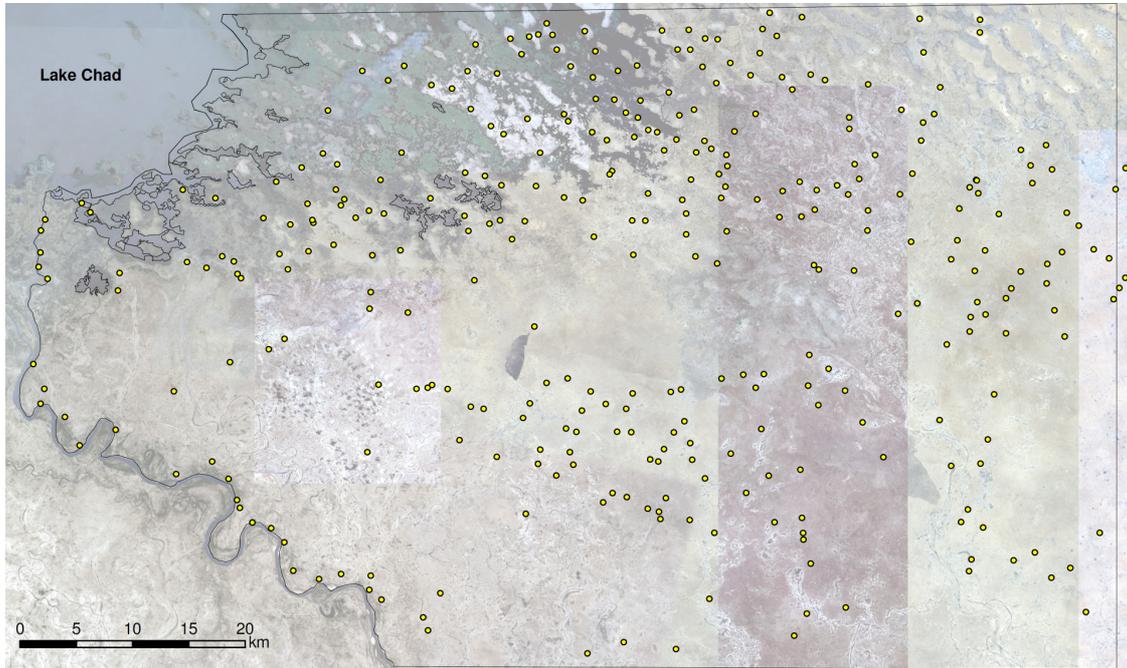


Figure 2.2: Density of permanent settlements (incomplete) in the studyzone.

In addition to utilization for subsistence farming, fertile land is increasingly being sold to entrepreneurs living in urban areas, who manage orchards or other agricultural enterprises, sometimes remotely. Although the World Food Programme (WFP), and other organizations, have been distributing food aid in recent years in the study area (WFP, 2012), interviewed community members stated that mobile pastoralists and most of the smaller villages had virtually no access to these supportive measures due to perceived arbitrariness in distribution, as well as political and logistical issues (see Chapter 1, 2013).

2.3 Methods

To estimate population density in the study area, 20 random coordinates were generated from a rectangular area which included the study zone and some reserve area. After the latitude/longitude coordinates were converted into an

equal-area projection, a sequence of points were randomly generated within the boundary circumscribed rectangle of the shape file, with the point generation condition set as a minimum distance of five km between points. Three points outside the study zone were eliminated and the remaining total was 17 (Figure 2.3).

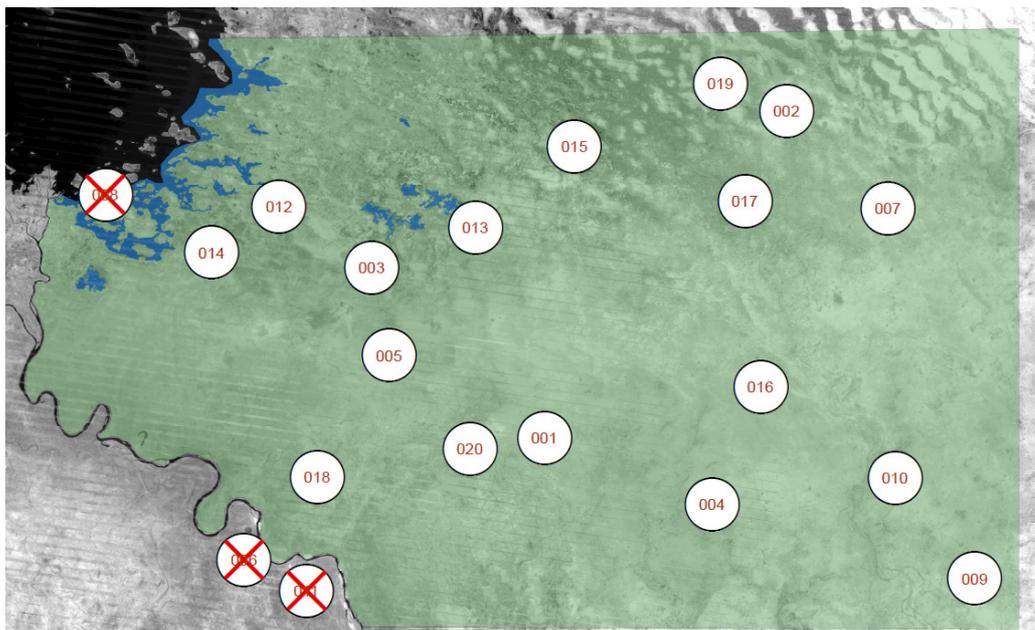


Figure 2.3: Random coordinates in the study area

Each of the remaining points was visited four times, twice at the beginning of the dry season (October - November 2010 and 2011) and twice at the end of the dry season (April - May 2011 and 2012). Using a hand-held global positioning system (GPS) device (Garmin eTrex 10), the selected points were located. The area around the points, including a 500 m radius, was scanned visually, often by climbing on the roof of the vehicle. A distance of one km was then measured from the original coordinates, and the central point was slowly circled at a one km radius. Collaborators with extensive local knowledge visually scanned the area on both sides of the route looking for camps and settlements. The same procedure was then repeated at a distance of two km (Figure 2.4). The assumed

visibility of 500m was a conservative value chosen to ensure identification of all camps and villages, based on a previous study in the area which assumed one km visibility (Weibel *et al.*, 2008)). With this approach, a circular area 5 km in diameter, with its center at the randomly selected coordinate, was covered. In each random coordinate surveyed ($n=17$) the total surface surveyed was 19.6 km².

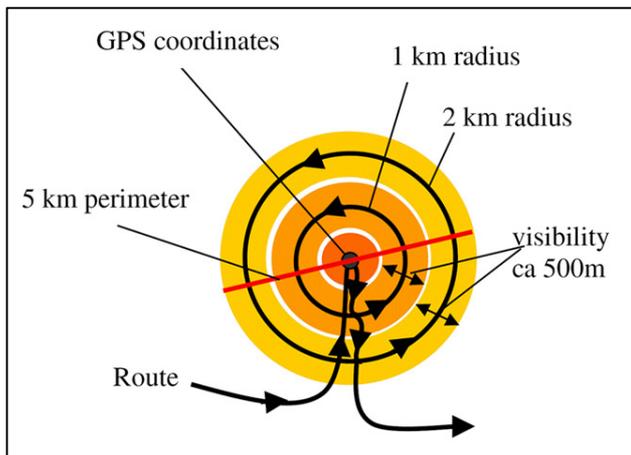


Figure 2.4: Schematic illustration of sampling method

When any sign of a camp or village, such as a roaming donkey or fresh droppings from sizeable cattle herds, indicated the proximity of a camp, the circuit was interrupted, and the research team approached the camp or village, registering its coordinates with the hand-held GPS device. If only a single person was seen, he or she was asked for directions to nearby camps or settlements. After the location registration, permission for an interview was requested, and if the camp or village leader was available, the interview was conducted immediately. Otherwise, an appointment was sought, usually for early morning the next day, and then the driving circuit was resumed at the previous point of deviation. The inclusion criterion was that the hut or tent of the village/camp leader ("*Boulama*") was inside the 2.5 km radius surrounding the random coordinates.

During the interview, the camp leader was informed about the study and asked for oral consent to participate. This approach was dictated by the very high

illiteracy rate in the study zone. An interview was conducted with the community leader, who was usually accompanied by male family and community members. Sometimes women also participated. Data from sedentary villages were only collected the first time they were encountered because the study was repeated at four intervals in the same locations. Interviews began with open questions to assess the livelihood priorities of the communities (see Chapter 1). Further questions were asked about the population of the community and the owned livestock. A community was defined as all the people who were traveling with the “*Boulama*” during transhumance, i.e., those for whom he was responsible. For villages, the community included all those for whom the “*Boulama*” was responsible. If a village was large enough to be divided into satellite villages, only satellites where the “*Boulama*” was dwelling within the coordinate perimeters were included.

All data were double entered in Microsoft® Access 2002 (Microsoft Corp.; Redmond, USA), and then the databases were examined with Epi Info™ 3.5.1 Data Compare program (Centers for Disease Control and Prevention). Discrepancies were corrected, and statistical analysis was done using Stata IC 10.1 (StataCorp LP, College Station, USA). Finally, these data were compared with data from a longitudinal surveillance study at the household level in the same area (Jean-Richard *et al.*, 2014) for triangulation.

Ethical considerations

Prior to initiating the study, ethical approval was given by the Ethics Commission of the cantons of Basel (Ethikkommission beider Basel, EKBB 316/08) and a research authorization was obtained from the Ministry of Health in Chad (Ministère de la Santé Publique, No 571/MSP/SE/SG/DGAS/2010). Oral consent was obtained from participants following a detailed description of the aims of the study. It was not planned for this interview study to collect a more formal consent form with fingerprint of the participant and signature of a witness in this highly

illiterate population. Any members of the interviewed camps who reported being sick were examined by a nurse and treated by local health staff. Consultations were offered without cost, and prescribed medications were provided at a subsidized price.

2.4 Results

The demographic study started in October 2010 with the assessment of the sedentary, mobile and livestock populations in the study area. Across the repeatedly visited 17 random coordinates, data from villages (n=42) and camps of mobile pastoralists were collected. At the beginning of the dry season (October-November), we found 11 mobile pastoralist camps in 2010 and 16 camps in 2011. At the end of the dry season (April-May), we located 34 camps in 2011 and 30 camps in 2012.

The median population was 129 people per camp and 167.5 people per village. Mobile pastoralist camps registered much higher numbers of animals, with 500 cattle and 500 small ruminants per camp compared to 30 cattle and 102 small ruminants per village (Table 2.1).

		Obs.	Median	25% - 75%
Population	Camp	91	129	65 - 210
	Village	42	167.5	76 - 420
Cattle	Camp	91	500	200 - 1100
	Village	42	30	0 - 150
Small ruminants	Camp	91	500	160 - 1500
	Village	42	102	50 - 420

Table 2.1 Number of villages/camps and mean population and livestock numbers per village/camp

Density of people and animals

In the sedentary population, we found an average of 64.0 people per km² (95% confidence interval (CI): 20.3 - 107.8). The numbers for mobile people were

much lower, at only 5.9 people per km² at the beginning of the dry season (95% CI: 2.3-9.5) and 17.5 people per km² at the end of the dry season (95% CI: 10.7-24.3).

Livestock from sedentary villages were on average 21.0 cattle per km² (95% CI: 1.3 - 40.7) and 31.6 small ruminants per km² (95% CI: 13.1-50.1). The mean values for mobile pastoralist animals were 66.1 cattle per km² (95% CI: 41.1-91.2) and 102.5 small ruminants per km² (95% CI: 35.2-169.8) (Figure 2.5).

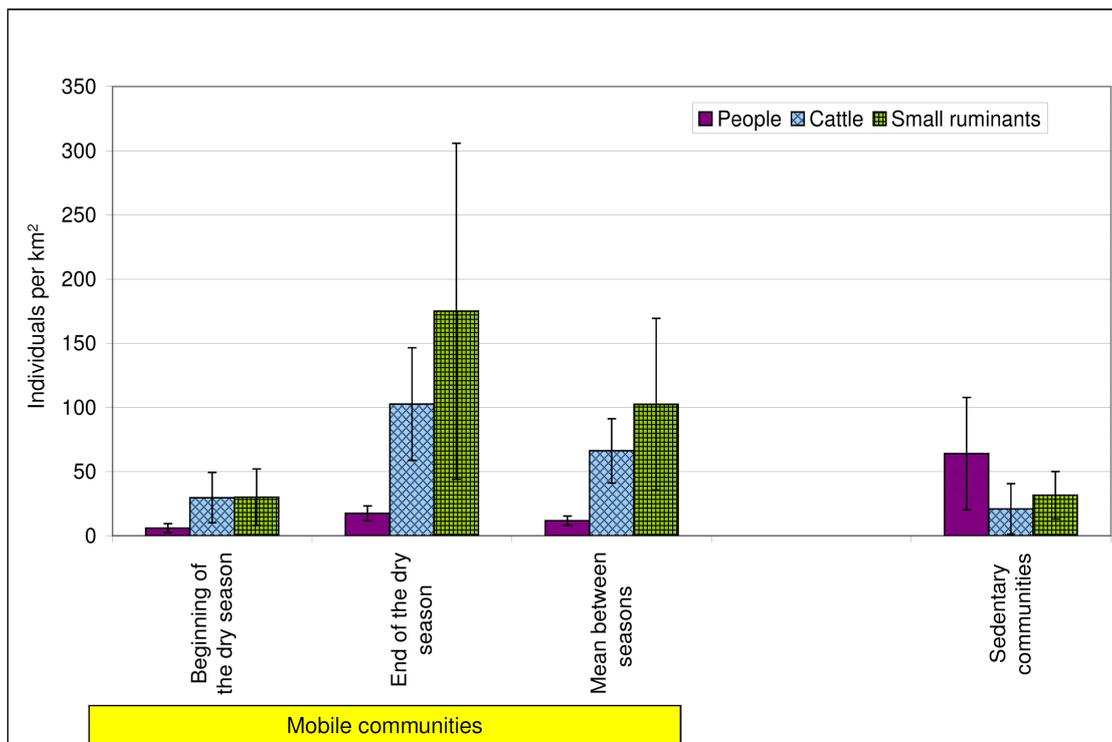


Figure 2.5: Density of people and animals from mobile pastoralists' camps and villages per km². Beginning of the dry season: October-November, end of the dry season: April-May

Although the numbers were much smaller than those registered for cattle and small ruminants, camels, donkeys and horses were also present in both sedentary and mobile communities (Table 2.2).

		Mean	95%CI min
Villages	Camels	0.2	0.0* - 0.6
	Donkeys	5.7	2.0 - 9.5
	Horses	1.9	0.6 - 3.2
Mean between seasons for mobile communities	Camels	4.1	0.0* - 9.0
	Donkeys	4.6	2.6 - 6.6
	Horses	1.5	0.9 - 2.0

Table 2.2: Density of other livestock (camels, donkeys and horses) of sedentary and mobile communities per km².

* confidence limits were truncated at 0.

The confidence intervals of the animal per person ratio for cattle, sheep and goats overlap with confidence intervals of data collected from households during a longitudinal surveillance study in the same area (Jean-Richard et al., 2014), as shown in Figure 6. However, it should be noted that the household level data represent only cattle breeding families who remain in in the study zone year round who were selected by convenience sampling rather than randomly, while the camp data represent all mobile pastoralists in the area at the time of sampling.

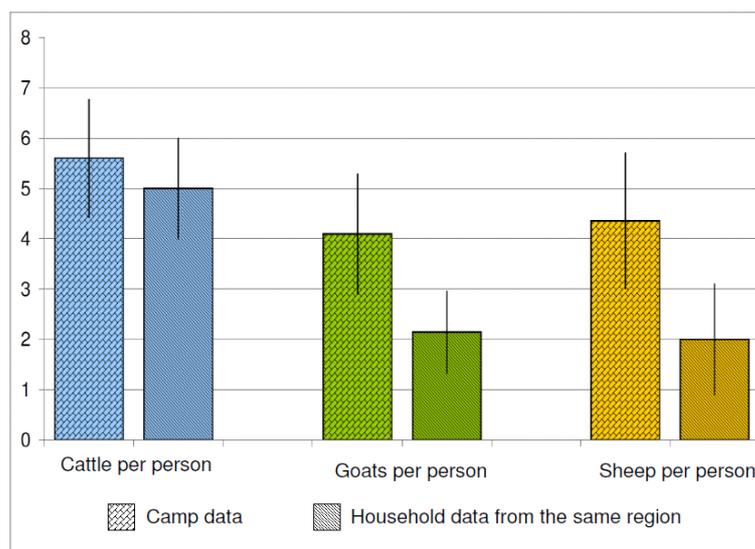


Figure 2.6: Comparison of livestock numbers per person between camps from density assessment and longitudinal household data from the same area and period

2.5 Discussion

To our knowledge, this study is the first to present information about the density of people and livestock on the Chadian side of Lake Chad. This study recorded an average of 64 people per km² in villages and 11.7 people per km² in mobile communities during the dry season. The average number of cattle was 21 per km² in villages and 66.1 per km² for mobile communities. In particular, the human and animal densities recorded at the end of the dry season are notably high.

The lack of access to pastures and the increasing pressure from sedentary communities on mobile populations and lifestyle was strongly emphasized by mobile pastoralist leaders (see Chapter 1). Some even stated a desire for the lake to return to the extensions of the 1960s so “it would flood all the fields of the settled people, and we would have access to pastures again and be free of the problems with the agricultural fields”.

The estimates by Thornton et al. (2002) seem very low for the Chadian side of the lake (maximum of 10 to 20 animals per km²), when compared to our results. When animal density is expressed in Tropical Livestock Units (TLU¹) as described by Jahnke (1982) and utilized by the Food and Agriculture Organization (FAO, n.d.), we calculate an average of 74.4 TLUs per km² during the dry season for cattle and small ruminants. Including camels, donkeys and horses there are an additional 12.2 TLUs per km², resulting in 86.6 TLU per km² during dry season.

Assuming an average rainfall of 400mm per year for the Chadian side of the lake basin (FAO, 1997), which is still higher than data from the World Bank (The World Bank, 2013) for the study area, the carrying capacity would be comparable to the estimates of 14 to 23 TLU/km² for other areas in the Sahel zone (Leeuw and Tothill, 1990) with similar rainfall and a single rainy season (Wylie *et al.*, 1987; Hiernaux, 1982; Le Houérou H.N. and Hoste C. H., 1977; Pratt *et al.*, 1977). We acknowledge that the concept of carrying capacity

¹ Cattle = 0.7 TLU; camels = 1 TLU; small ruminants = 0.1 TLU; donkeys = 0.5 TLU; horses = 0.8 TLU

continues to be debated (Scoones and Graham, 1994). Nevertheless, the contrast between the estimated carrying capacities and the high TLU/km² found in our study area is remarkable. It is reasonable to further conclude that fodder could be insufficient for the number of animals, with overuse of pastoral resources contributing to emaciation in animals and, further, malnutrition of people in the area.

One could argue that over 13% of the study area vegetation is growing throughout the year (Figure 2.1), but, importantly, an increasing proportion of this land is in agricultural use and no longer available to pastoralists. Additionally, many areas of the green zones are taken up by villages, further decreasing accessible pasture areas to mobile pastoralists. Our calculations have considered the entire surface area of the surveyed coordinates, even though some areas are not available for grazing livestock. Therefore, this method was considered to be a conservative estimate.

Although they are well aware of the problem, pastoralists are reluctant to reduce herd sizes. The strategy of owning as many animals as possible is reinforced by insecurity, thereby providing a means of resilience to mobile pastoralists through balancing losses from disease and lack of feed caused by pasture unavailability. The Chadian government estimates that the animal numbers in the Sahelian zone of Chad have grown from 12 million TLU in 2000 to 16 million TLU in 2010, an increase of 33%, and it is expected that the number will further increase to 21 million TLU by 2020 (MERA, 2008). Increasing livestock numbers in the area were also observed by Wiese (2006).

Sedentarization of pastoralist families is frequently observed. Some mobile communities also stated that they desire to become sedentary but have been unable to obtain land to settle and farm. Other communities purchase land for grazing animals, but it is not sufficient to maintain their herds over an entire year. A stable political system and functional infrastructure are needed for mobile pastoralists to provide alternatives to maximising herd size. Regulations for pasture and agricultural land use must be developed and implemented and

veterinary services must be improved in order to guarantee health maintenance in smaller herds. Also, mobile pastoralists must have access to stable equitable, alternative investments, for example, land or estate property and bank accounts, as a pre-condition for a meaningful change of strategy towards more sustainable and equitable land management.

The situation in the study area parallels the “tragedy of the commons”, described years ago by Hardin (Hardin, 1968) in the context of a system in which rational individuals have freedom to use common resources to pursue individual gain without imposed limits. It was used as a justification to privatise rangeland, which has paradoxically not led to the anticipated higher productivity (Fratkin and Mearns, 2003; Scoones and Graham, 1994; Turner, 1993). Hardin’s assumption of complete absence of regulations is rarely true in actuality since most rangeland is governed by traditional regulations which allocate at least some rights (Peters, 1994; Turner, 1993; Bromley and Feeny, 1992). However, in the study area, the lack of binding regulations is increasingly becoming an important issue (Figure 2.7). There is clearly a need for a new integrated institutional framework to regulate the governance of natural resources, especially with regard to pasture and water access.

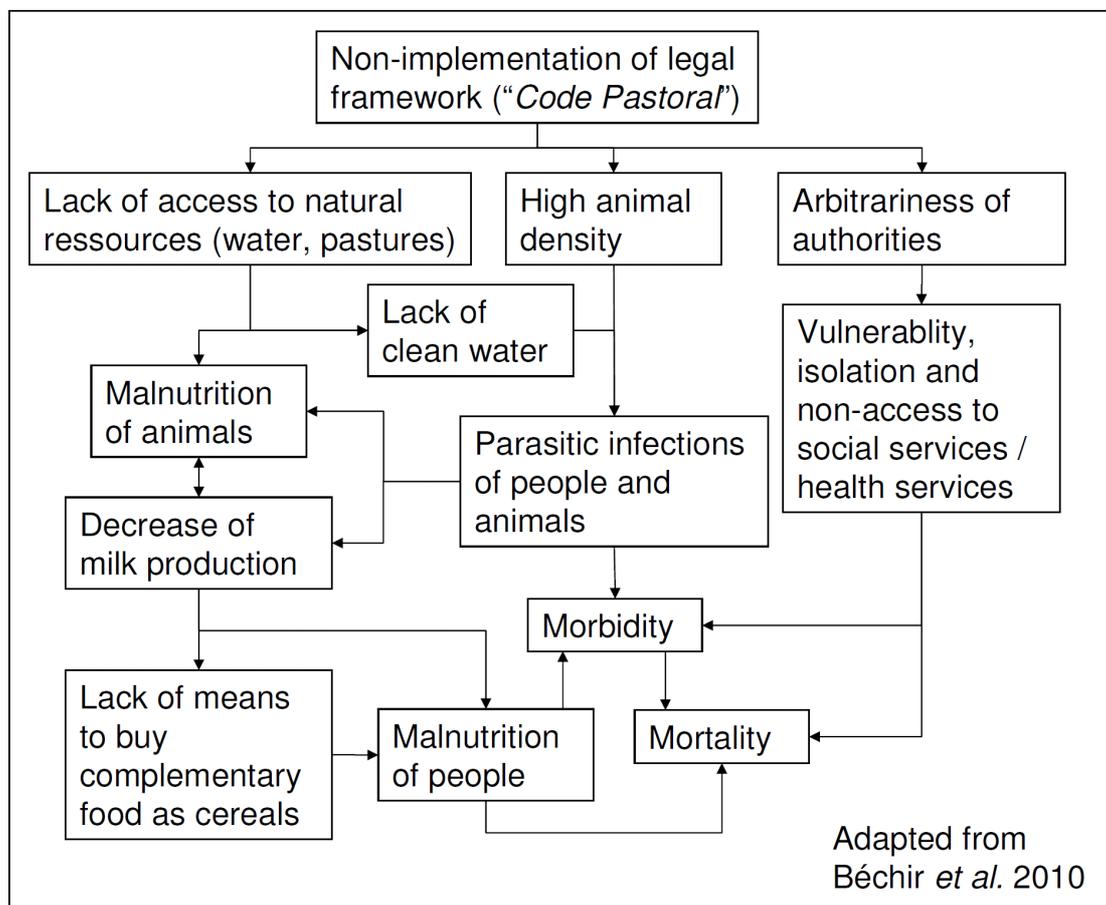


Figure 2.7: Implications of the non implementation of an institutional framework for mobile pastoralists

Policy implications

Bechir (2012) called for the implementation of a “minimum service package” to pastoralists as a condition for social peace, food security and resource accessibility. Such a package should provide for basic human and animal healthcare as well as education and emphasizes the need for a legal and binding institutional framework for mobile pastoralism. He further states that there are five dimensions of capital (Goodwin, 2003) which have to be strengthened to achieve sustainable development for pastoral communities, including social capital such as family and social networks, natural capital like pasture and water access, human capital by education, financial capital and, finally, physical capital

through infrastructure. Moreover, pastoralists should be encouraged to destock their herds with adapted measures (Bechir, 2012).

The call for a new institutional framework has been made repeatedly in mobile pastoralist research in the southeastern Lake Chad area (Montavon *et al.*, 2013; Bechir, 2012; Wiese, 2006; Fokou *et al.*, 2004). Regulations to legislate land use and pastoralist movement cannot be imposed from the outside, but rather must be actively developed by the government and ministries with participation from representatives of the concerned populations. In Chad, a new Pastoral Code has been drafted and is being reviewed by the livestock ministry; however, there are many conflicting interests involved, and progress has been very slow (International Crisis Group, 2014). Although a cross-sectoral project for the benefit of mobile pastoralists is being undertaken by the Ministry of Planning, the frequent turnover of ministers has slowed down decision processes considerably. Moreover, the initial concept of an inter-sector policy involving health, education and environment cannot be easily put into action because ministries generally restrict planning to their own sector. The Ministry of Health currently has a Directorate for health of hard-to-reach populations and this Directorate should take the lead in coordination between Ministries. Recently, this demand for a new legal framework has been taken up by an association of young pastoralists (Association des Jeunes Pasteurs du Tchad), comprised of several ethnic groups, with the aim to politically represent the mobile pastoralist community, and they have been recognized by the national parliament. They have anecdotal success in the areas of health service provision, legal assistance and information exchange through networking.

Limitations of the study

Our data should be interpreted with caution because all population and herd numbers are reported data which cannot be readily verified, despite the long tradition of collaboration between researchers and the local population which provided a trustworthy basis for data collection. Animal numbers may have been

too large for a valid count. However, the data concerning animal numbers is nonetheless likely to have been underestimated since mobile pastoralists are reluctant to answer questions concerning numbers of livestock stemming from concern that the data might be used for taxation purposes (Homewood and Randall, 2009). Notably, the reported animal per person ratio is comparable to numbers recorded during a small scale demographic survey within the communities (Jean-Richard *et al.*, 2014). Finally, data were highly dynamic over the collection period of two consecutive years. A longer study period might have led to a wider range of registered outcomes, thus yielding a more accurate estimate over time.

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We would like to thank the study participants and their families for patience and openness to participate in the interviews. Our partners in N'Djaména, the Centre de Support en Santé Internationale (CSSI), are thanked for invaluable contributions and support. Jan Hattendorf provided significant expertise facilitating the statistical analysis. The Swiss National Science Foundation (SNF) is greatly appreciated for generous financial support.

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Chapter 3

The use of mobile phones for demographic surveillance of mobile pastoralists and their animals in Chad: proof of principle

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3.1 Abstract

Background: Demographic information is foundational for the planning and management of social programmes, in particular health services. The existing INDEPTH network surveillance sites are limited to coverage of sedentary populations. Including mobile populations in this approach would be expensive, time consuming and possibly low in accuracy. Very little is known about the demography of mobile pastoralists and their animals, so innovative approaches are urgently needed.

Objective: To test and evaluate a mobile demographic surveillance system for mobile pastoralist households, including livestock herds, using mobile phones.

Design: Mobile pastoralist camps were monitored (10 for 12 months and 10 for 18 months) using biweekly mobile phone calls with camp leaders and their wives to conduct interviews about the households and livestock. The collected information was validated through personal visits, GPS data and a livestock demographic model.

Results: The study showed the feasibility of mobile phone surveillance for mobile pastoralist camps, providing usable, valid information on human and livestock population structures, pregnancy outcomes and herd dynamics, as well as migration patterns. The approach was low-cost and applicable with the existing local resources.

Conclusion: Demographic surveillance in mobile populations is feasible using mobile phones. Expansion of the small-scale system into a full mobile demographic surveillance system is warranted and would likely lead to improved planning and provision of human and animal health care.

Key words: mobile phones, mobile pastoralists, demographic surveillance, herd surveillance, one health

3.2 Background

Demographic information is essential to expand concepts of social development and to plan land management and social programmes, in particular health services. Without demographic data, it is challenging to accurately assess the effectiveness of interventions (1).

To address the lack of national demographic information systems in developing countries, the international INDEPTH network has developed demographic and health surveillance systems in many locations around the world. In 43 sites in 20 countries, a population of 3.2 million people is collectively followed with regular visits to update demographic parameters (2). However, these surveillance sites have been limited to coverage of sedentary communities. Very little is known about the demography of mobile populations such as working migrants or mobile pastoralists and their herds. Only a handful of studies with demographic indices in African mobile pastoralists are available (3–8). In Chad, one of the poorest countries of the world, estimates of the mobile pastoralist population range from less than 400,000, or 3.5% of the total population in the 2009 national census, up to 2 million (9, 10). Despite the low numbers, these populations are reported to own about half of the livestock and generate about half of the national meat production (10), representing great economic potential. Although several authors have previously described the mobile pastoralist populations in the Lake Chad area (1, 11), longitudinal data on demographic development of the human and animal populations is lacking (12, 13).

For health services, existing local systems are not conceptualised to include mobile populations, for example, to overcome the obstacles of cultural and language-related access problems (14, 15). Additionally, mobile communities face discrimination in health centres (16). An earlier study showed that livestock had much better vaccination coverage than did children less than 5 years of age,

none of whom had been completely immunised according to the recommended programme. Subsequently, a programme of simultaneous vaccination for animals and children was introduced and sustained in the area for 5 years, resulting in a much higher vaccination coverage rate in children (17–19).

There is clearly a need for adapted, integrated services as well as for the establishment of demographic baseline data. Demographic surveillance as developed for sedentary communities is not feasible with mobile pastoralists, because the regular visits need to take place in different locations depending on migration routes. This is costly and time consuming, involving enormous logistical efforts. However, without such basic information, the health services cannot adequately plan to include pastoralists in either fixed or outreach services.

Demographic surveys for African mobile populations have mainly been conducted to generate information on fertility and mortality rates (20) rather than to estimate population sizes and densities. In demographic population surveys or censuses, mobile pastoralists, or even entire regions where they are a majority, were often excluded (21). Alternative methods have been used previously, for example, the 'water-point approach' where data is collected at the water bodies and wells used by mobile pastoralists, but these are limited by high personnel costs and logistical issues (16). Another approach is aerial censusing, which requires validation for people and complementation with field data, e.g. for household structures (22). A significant shortcoming of this approach for the Lake Chad area is that people and animals often shelter under trees during hot periods of the day. Weibel et al. tested an adaptation of the population ecology capture–mark–recapture method to estimate the population size in the south-eastern Lake Chad area using biometric fingerprinting and random transects (1). Although this method proved to be feasible, the recapture probability was too low for an accurate estimation in the large population that spread over several countries.

The benefits of using mobile phones for health information and interventions have been shown in developing country settings, using text messages (23) and phone calls (24, 25). The benefits of mobile phone use have additionally been described in animal health and disease control (26, 27). In the last decade, mobile phone communication increased rapidly in Africa, to 45% penetration across the continent (28). While one in three Chadians owned a mobile phone by the end of 2011 (29), penetration rates in Chad are reported to be well below the African average, with patchy network coverage particularly in rural areas (30). Most of the mobile pastoralist camps (consisting of an extended family group) in our study area had at least one household that owned a mobile telephone (personal observation). It is expected that coverage will steadily increase and this will be associated with internet availability.

Since demography of mobile settlements includes many locations due to the movement of communities, it is also important to collect data about the transhumance routes. Data in Gorane and Arab communities in the area were collected by Wiese in 1998 and 1999 using participatory mapping (31), but the reporting was not in real time.

The objective of this study was to test and evaluate a new method for demographic surveillance of mobile communities and their livestock using mobile phones. We call this a mobile demographic surveillance system (mobile DSS) because the covered populations have, at least partially, a mobile lifestyle. We combined animal and human demographic surveillance because of the close interactions of the study population with livestock, because of our previous experiences with combined human and animal health interventions (17, 32) and in order to capitalise on the added value of the 'one health' approach (33).

3.3 Present investigation

Study population

The study site was located to the southeast of Lake Chad, bordering the lake and the Chari River. The zone extended 100 km from east to west and 50 km from north to south. The study population consisted of mobile pastoralists from three ethnic groups that utilised different livelihoods and husbandry practices. The Foulbé, also called Peul or Fulani, herded the animals close to the riverbanks or open water bodies of Lake Chad. They preferred to graze their animals at the lakeshore, with the animals often standing in the water to feed. In contrast, the Gorane, or Dazagada, generally stayed in drier areas, watering the animals at wells, which capitalised on their considerable well building skills. The third mobile group in the study area was semi-nomadic Arab people, who lived in villages, only moving towards the lake when pasture resources around the villages become depleted towards the end of the dry season.

Design

The longitudinal study started with 10 camps (4 Foulbé, 3 Gorane and 3 Arab), and the number was increased to 20 camps after 6 months (8 Foulbé, 7 Gorane and 5 Arab), all of which then participated for an additional 12 months.

Method

Willingness to participate was ascertained with the head (Boulama) of each mobile pastoralist camp. After initial agreement, in accordance with cultural norms, the head designated the herd to be included in the study, either his own or that of a son. A camp herd was defined as the animals that were regularly kept together, often including several, closely related households. The camp herds included cattle, goats, sheep, camels, donkeys, horses and chickens. All participating communities were primarily cattle breeding communities. The designated camp herd, along with the households to which the included animals belonged, was enrolled in the cohort. A household was defined as the members

who eat and live together. Usually, each wife had her own household, so the husband was counted only in the household of his first wife.

Every 2–4 weeks, a telephone interview was conducted, first with the leader of the camp (or the specific camp herd), who provided information about the herd, and then with his wife who provided information about family members of all included households. It was a priority to involve both men and women in the study in order to get more complementary information. If the wife was unavailable, the entire interview was conducted with the male participant. Interviews were conducted in the local language of each ethnic group or in Chadian Arabic, and the data were then translated into French to complete the questionnaires. After each phone interview, 1,000 FCFA (about US\$2) was transferred to the participant's phone as a small compensation for participation. The transfer amount was doubled if the wife also participated in the interview, which was an effective incentive resulting in substantial female participation. The calls were made from a central village in the area, Grédaya, where there is also a weekly market, which is often visited by mobile pastoralists. The interviewer was a local health worker who was well known to the pastoralists. He made an appointment with each participant prior to every phone interview, followed by a reminder a few days prior to the appointment. This approach led to high compliance as the participants made great efforts to attend the interviews, reportedly climbing trees or travelling to nearby places with reliable network coverage.

During each telephone interview, the positions of the camp as well as the distance from the last camp location were orally reported. The narrative description of the localisation was transferred to an oversized Google Earth map (Google Inc., Mountain View, CA, USA) with a scale of 1:25,000 of the study area. The resolution allowed for visual identification of the villages, and positions of camps were localised and geo-referenced. The positions were validated during

field visits, when the positions were recorded with GPS devices. The distance between the reported and actual position was calculated using ArcMap 9.2, which was also used for visualisation of the routes (Figs. 6–8).

During the interviews, data were collected about the presence or absence in the camp of each family member, as well as the number of pregnant women, births and deaths. As the communities did not always specifically record the birth dates of babies, we approximated all birth dates to be the middle date between two consecutive interviews.

For the livestock, participants were asked about camp herd structure, births, deaths, sales and purchases of animals, as well as animals taken in or entrusted to other pastoralists. The data on cattle were internally validated and cross-checked between the questionnaires.

Data were collected about cattle, goats, sheep and camels, divided by sex and age group (less than 1 year, 1–2 years and 2 years and older). For cattle, castrated males used for transportation of goods were also counted. We assumed age of first calving of cattle to be 3 years of age (21), which necessitated the inclusion of an adjusting factor to estimate the proportion of females above 3 years of age. Female cattle aged between 1 and 3 years were defined as heifers. As a reference, we used data from Gambia (34). Additionally, data were collected about donkeys, horses (juvenile and adult age groups) and chickens.

The information was recorded on paper questionnaires. Data were double-entered using Microsoft® Access 2002 (Microsoft Corp.; Redmond, USA), compared with Epi Info™ 3.5.1 Data Compare program (Center for Disease Control and Prevention, Atlanta, GA, USA) and cleaned. Statistical analysis was done with Stata IC 10.1 (StataCorp LP, College Station, TX, USA). ArcGIS 9.3

(ESRI Inc. ArcMap™ 9.3, Redlands, CA, USA) and Quantum GIS 1.8.0-Lisboa (OSGeo, Beaverton, OR, USA) were used for geospatial analysis. A demographic cattle model, using cumulated data from the interviews, was generated with Vensim version 6.0 (Ventana Systems, Inc. Harvard, MA, USA). Parameters were optimised on the basis of goodness-of-fit, or 'payoff', in Vensim software by comparing the log likelihood of the current model with the log likelihood of a perfect model, with the number of parameters equal to the number of data points. Data on female cows above 3 years of age were adjusted with an adjusting factor, since collected data included all cattle older than 2 years. Birth rates were calculated for each sex and net change rates for each sex and age group.

All members of the participants' camps who reported illness had access to local health staff during a field visit at least once during the study period. On this occasion, free consultation and examination was provided to all camp members present. Any necessary medications were provided at low cost to the patients. In addition, an emergency service for medical and veterinary problems was established, which continues to date. When a health emergency occurred, participants could telephone a local health worker in Grédaya, who would then travel to their camp. Using a cost sharing system, the participants paid for any medications needed, while the demographic surveillance project paid the transportation cost for the health personnel.

Ethical approval for the study was granted by the Swiss Ethics commission of Basel (EKBB 316/08), and a research permit was also obtained from the Ministry of Health of Chad (No 571/MSP/SE/SG/DGAS/2010).

3.4 Results

Cohort

A total of 490 telephone interviews were conducted. No enrolled camps were lost to follow-up. The telephone-cohort included 20 camps with one camp herd each and a total of 83 households (range 3–7 per camp). Usually all of the households stayed with the animals, with the exception of one Arab family, where only the herder and his family travelled with the animals throughout the mobile period, while the families of the owners remained in the village. Ten camps were followed for 18 months, participating in 30 interviews each. Six months after the study was initiated, an additional 10 camps were added, which participated in 19 interviews each during the following year.

At the mid-point in November 2011, the small-scale cohort consisted of 579 people, 2,869 cattle, 1,183 goats, 1,198 sheep, 338 donkeys, 99 horses, 35 camels and 315 chickens. All participants complied with the study until closure, resulting in zero dropouts. The mean number of livestock per person was 5.0 cattle (95% CI: 4.0–6.0), 2.0 sheep (95% CI: 0.9–3.1) and 2.1 goats (95% CI: 1.3–3.0).

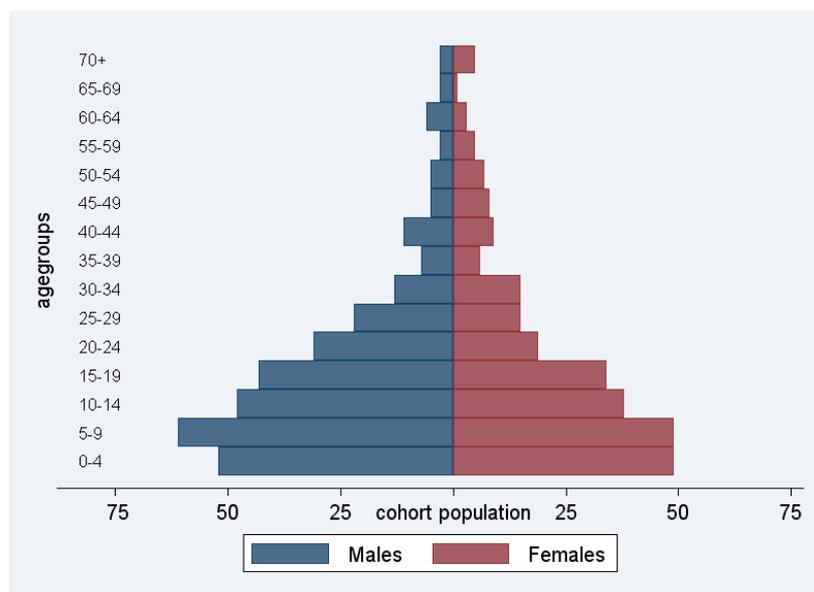


Figure 3.1: Age distribution of the human cohort in November 2011

One household consisted, on average, of 7.17 household members (SD=2.89) with a minimum of 2 and a maximum of 14 household members. Three households were headed up by women. The number of people per camp ranged from 16 to 55 people belonging to one camp herd of livestock (mean 28.9; SD 9.97).

During the study period, the births of 16 children were recorded. From all reported pregnancies (n=24), 42% (n=10) did not result in live births, with nine ending in spontaneous abortion and one in stillbirth. Fourteen women had live births, of which two women gave birth to twins. One of the nine miscarriages recorded twin foetuses. The average number of days between first reporting (pregnancies first reported at the beginning of the study period were exempted) and live birth was 152 days (SD: 90, min: 44, max: 251).

During the study period, three deaths were reported: two females aged 10 and 19, respectively, and one male aged 28. The reported cause of death in all cases was disease. Three individuals left the cohort, one due to employment and two due to outside marriage. Two children joined the cohort after temporarily living with extended family in another village. The 16 neonates were added to the cohort.

In two cases, entire households separated from the others, dividing the herds due to pasture scarcity (Fig. 2), and one household entrusted their animals to others to facilitate working in their fields. During the rainy season, when there was new growth in the pastures and after the harvest was completed, the households reunited.

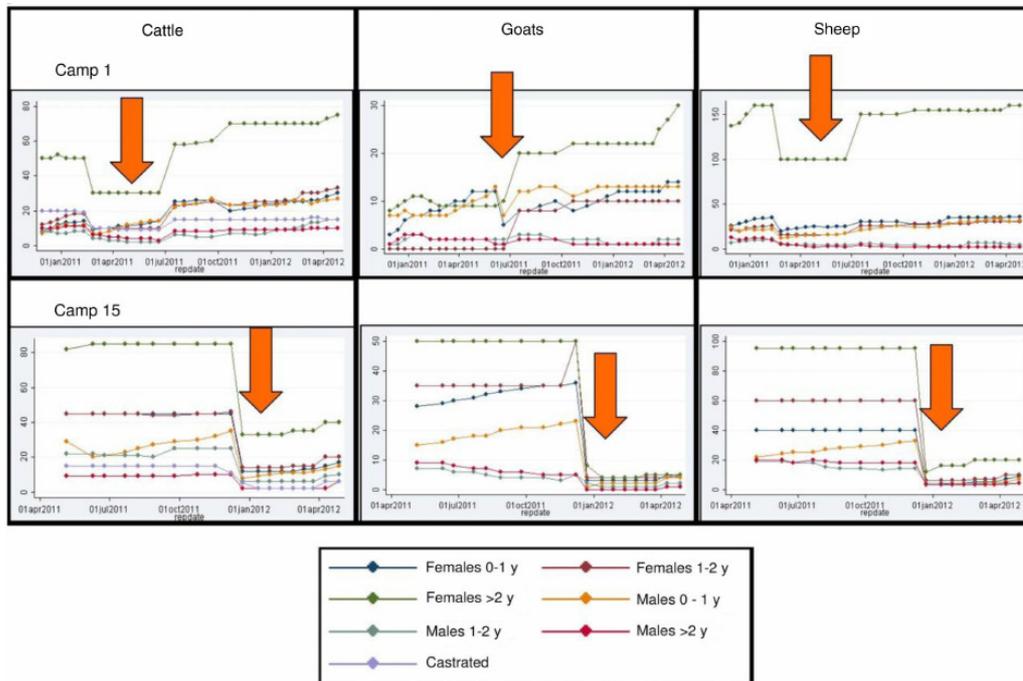


Figure 3.2: Herd splitting to manage dry season resource scarcity

One wife had, on average, 5.0 living children. Other children in the household were from the extended family, with only one case of an unrelated herder boy residing in a household. There was an average of 3.8 children below 16 years of age in the household, with 1.2 being under 5 years of age. No child attended regular school, although eight boys (between 8 and 23 years) attended Koranic schools in larger villages or towns. Menopausal women (older than 50 years) where the youngest child was still living in the household (n=7), had an average of 7.0 living children.

The median animal numbers per herd including all animal species are summarized in Table 3.1.

Table 3.1. Average animal numbers for herds

	Mean	SD	Min.	Max.
Cattle	143.5	66.6	47	258
Goats	59.2	49.0	0	150
Sheep	59.9	78.2	0	259
Camels	1.8	2.3	0	8
Donkeys	16.9	18.3	2	87
Horses	5.0	3.0	1	16
Chicken	15.8	12.0	0	33

Table 3.2 shows the average number of cattle and small ruminants per herd stratified by age group and sex and the proportion of each group in the species-specific herd.

Table 3.2. Average animal number and proportion of each age group and sex in species-specific herds

	Female animals					Male animals				
	Mean	% of herd	SD	Min.	Max.	Mean	% of herd	SD	Min.	Max.
Cattle 0–1	19.9	14	8.3	7	45	18.9	13	6.3	6	32
Cattle 1–2	18.6	13	9.9	5	45	8.3	6	5.8	0	25
Cattle 2+	66.6	46	39.6	20	170	6.2	4	5.7	1	25
Castrated						5.1	4	6.1	0	19
Goats 0–1	12.4	21	10.8	0	35	11.3	19	9.6	0	32
Goats 1–2	11.6	20	10.5	0	35	1.6	3	1.8	0	8
Goats 2+	21.7	37	19.1	0	70	0.7	1	1.2	0	5
Sheep 0–1	10.4	17	12.3	0	40	9.4	16	10.9	0	32
Sheep 1–2	11.1	18	15.0	0	60	1.5	2	3.1	0	14
Sheep 2+	26.1	44	39.0	0	155	1.5	3	4.0	0	18

The fertility rate per year for small ruminants was 1.09 kids per adult female goat ($n=433$) and 0.76 lambs per adult female sheep ($n=522$). Adult ruminants were considered as those aged 2 years and older. For cattle, the cow–calf ratio was 0.68 calves per cow (3 years and older; $n=1,145$). Juveniles (<1 year) comprised 39% of donkeys and 32% of horses

Cattle herd development model

The The data of all cumulated cattle herds were used to establish the parameters of a herd model shown in Fig. 3.3. The best fit is shown in Figs. 3.4 and 3.5. Parameters are described in Table 3.3.

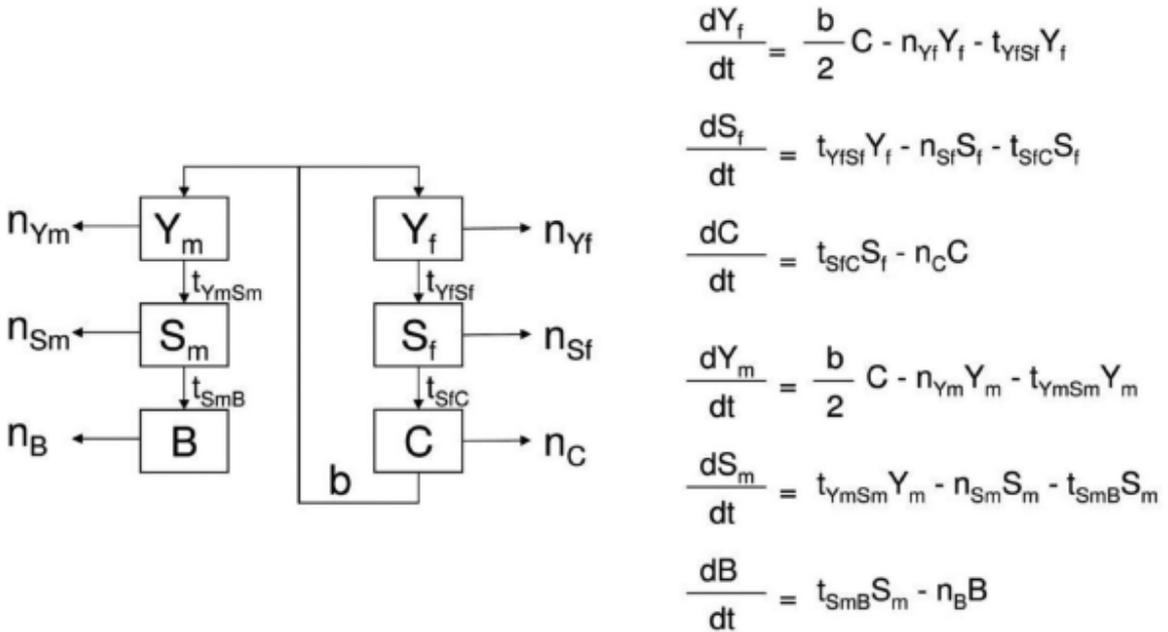


Fig. 3.3. Livestock demographic model and equations, where Yf=young females 0–1 year, Ym=young males 0–1 year, Sf=Heifers 1–3 years, Sm=young bulls 1–2 years, C=cows from 3 years, B=bulls from 2 years, m=mortality (including off-take), b=birth rate (including acquisition), a=age class transition.

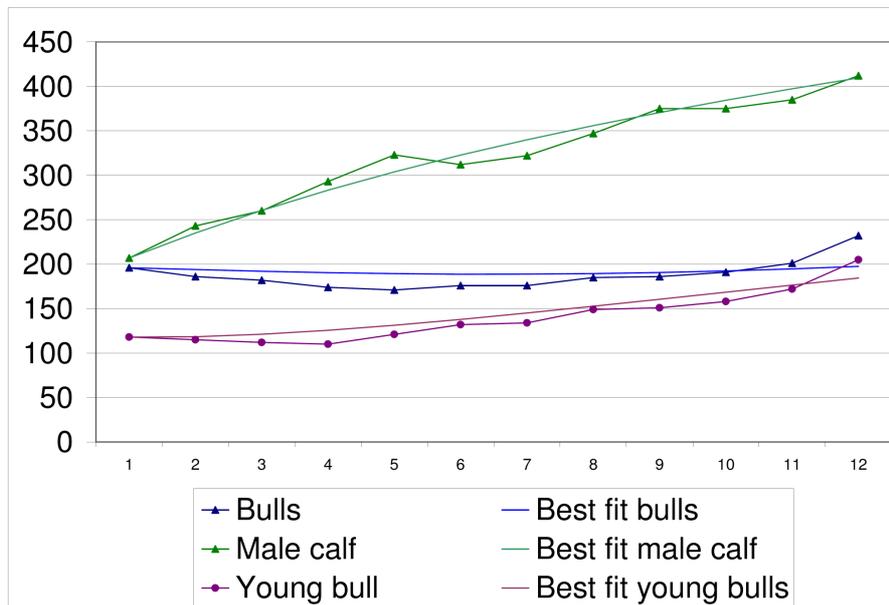


Fig. 3.4. Demographic model fit for male cattle during the time period of 1 year.

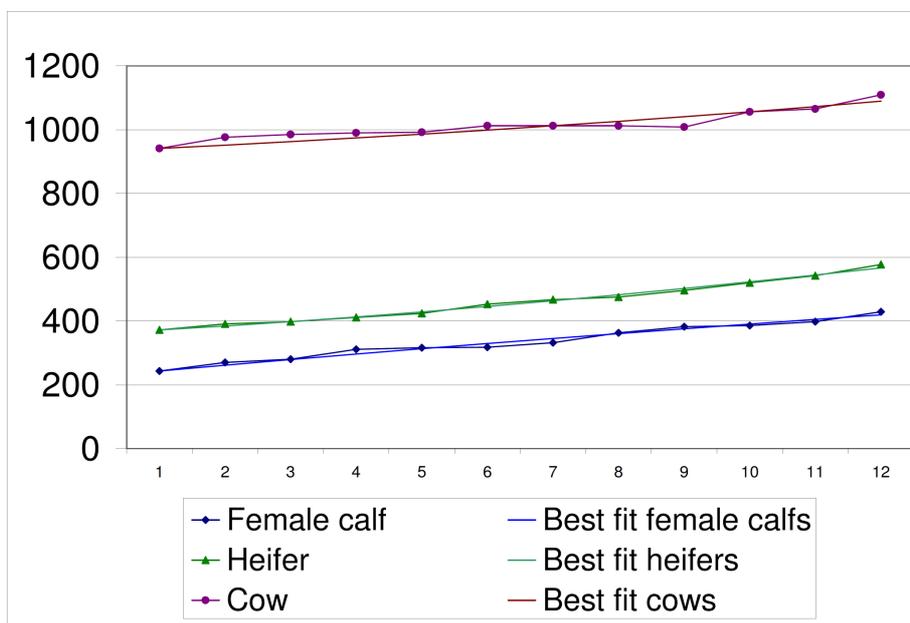


Fig. 3.5. Demographic model fit for female cattle during the time period of 1 year.

Table 3.3. Best-fit parameters for birth rate and mortality per year

	Lower boundary	Best fit	Upper boundary
Birth rates			
Female calves	0.0	0.4	0.5
Male calves	0.6	0.7	0.8
Mortality			
Male calf	0.2	0.5	0.8
Young bull	0.4	0.7	1.1
Bull	0.6	0.7	0.8
Female calf	-0.6	-0.5	-0.1
Heifer	-0.4	-0.2	-0.1
Cow	0.0	0.1	0.1

Geospatial data of tanshumance routes

To validate the oral position descriptions reported by camp leaders, GPS coordinates of 19 camps were recorded, using a Garmin eTrex 10 handheld device, during routine visits for comparison to the reported positions. The average distance between the described and actual positions was 1.79 km (minimum 0.4, maximum 4.0 km).

When stratified by ethnic group, a clear pattern of spatial distribution emerges. Foulbé people herd their animals in close proximity to the water bodies of Lake Chad (Fig.3. 6). In contrast, Gorane people, who are skilled well builders, avoid the shore areas for their camps (Fig. 3.7). Arab cattle breeders, who are semi-nomadic, remain in their villages as long as there is grass in the surrounding pastures, only moving closer to the lake towards the end of the dry season as resources become scarce (Fig. 3.8).

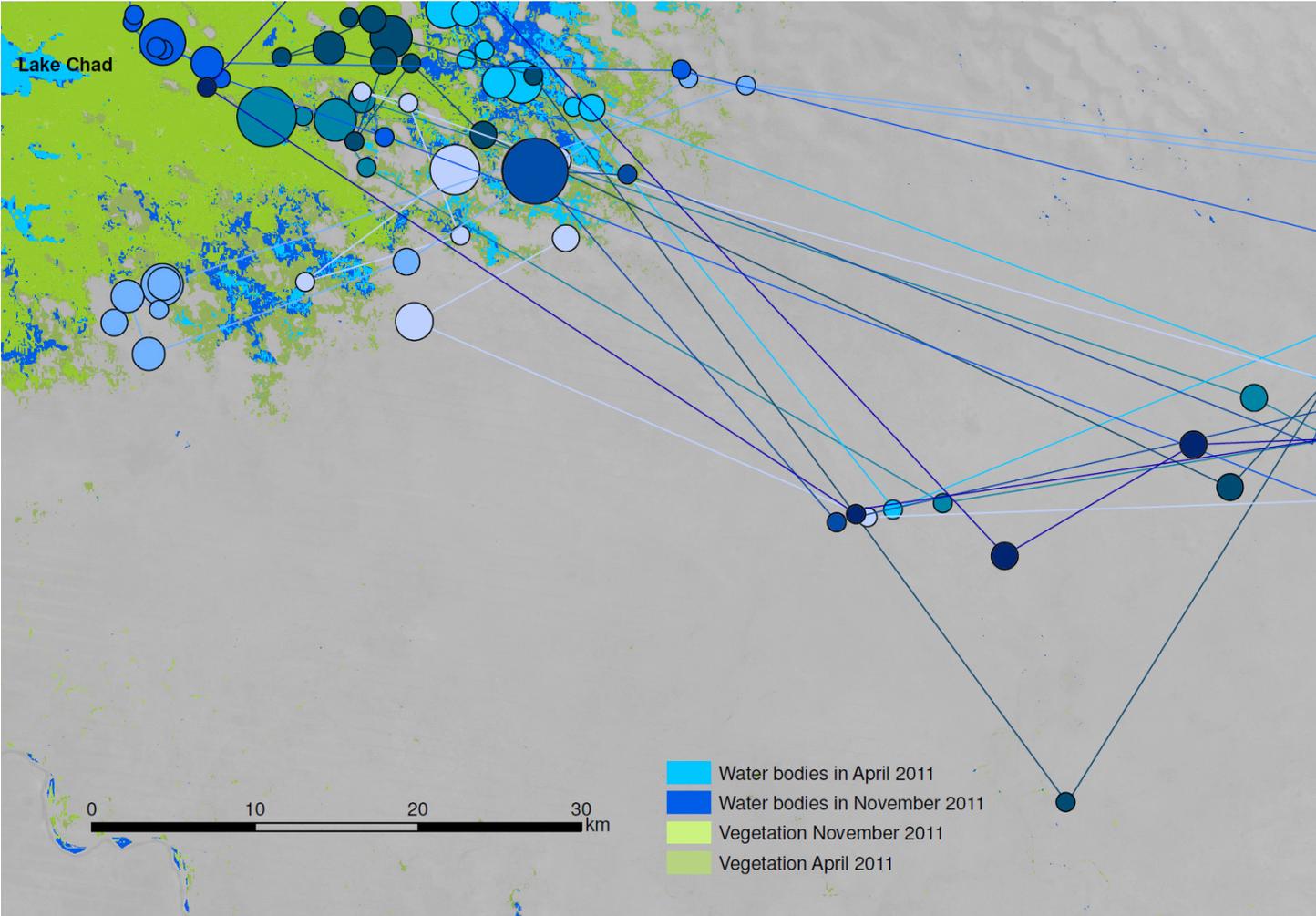


Figure 3.3: Movement of Foulbé communities in the study zone. Circle size indicates the length of stay in each position. Each colour represents a different community

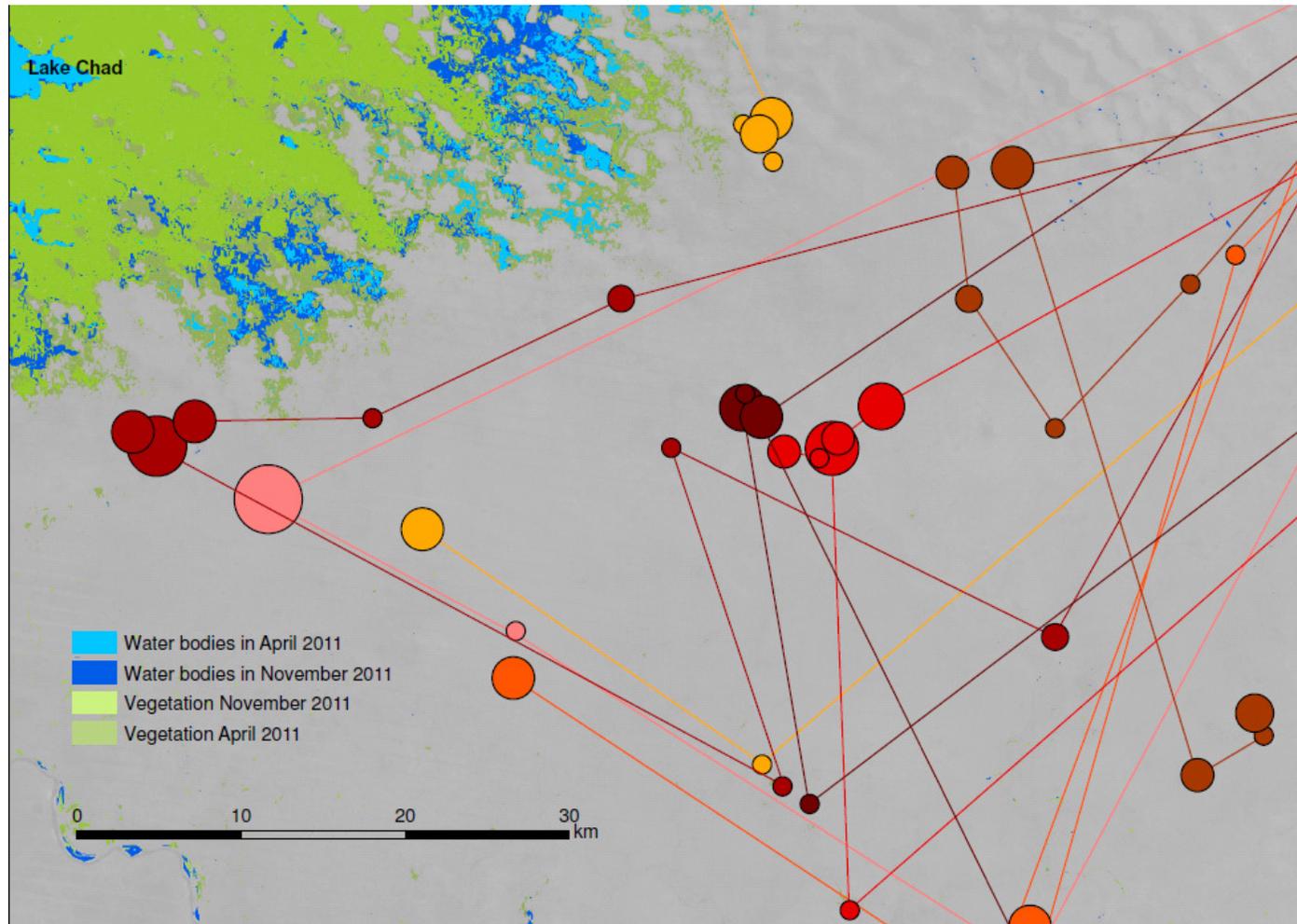


Figure 3.4: Movement of Gorane communities in the study zone. Circle size indicates the length of stay in each position. Each colour represents a different community

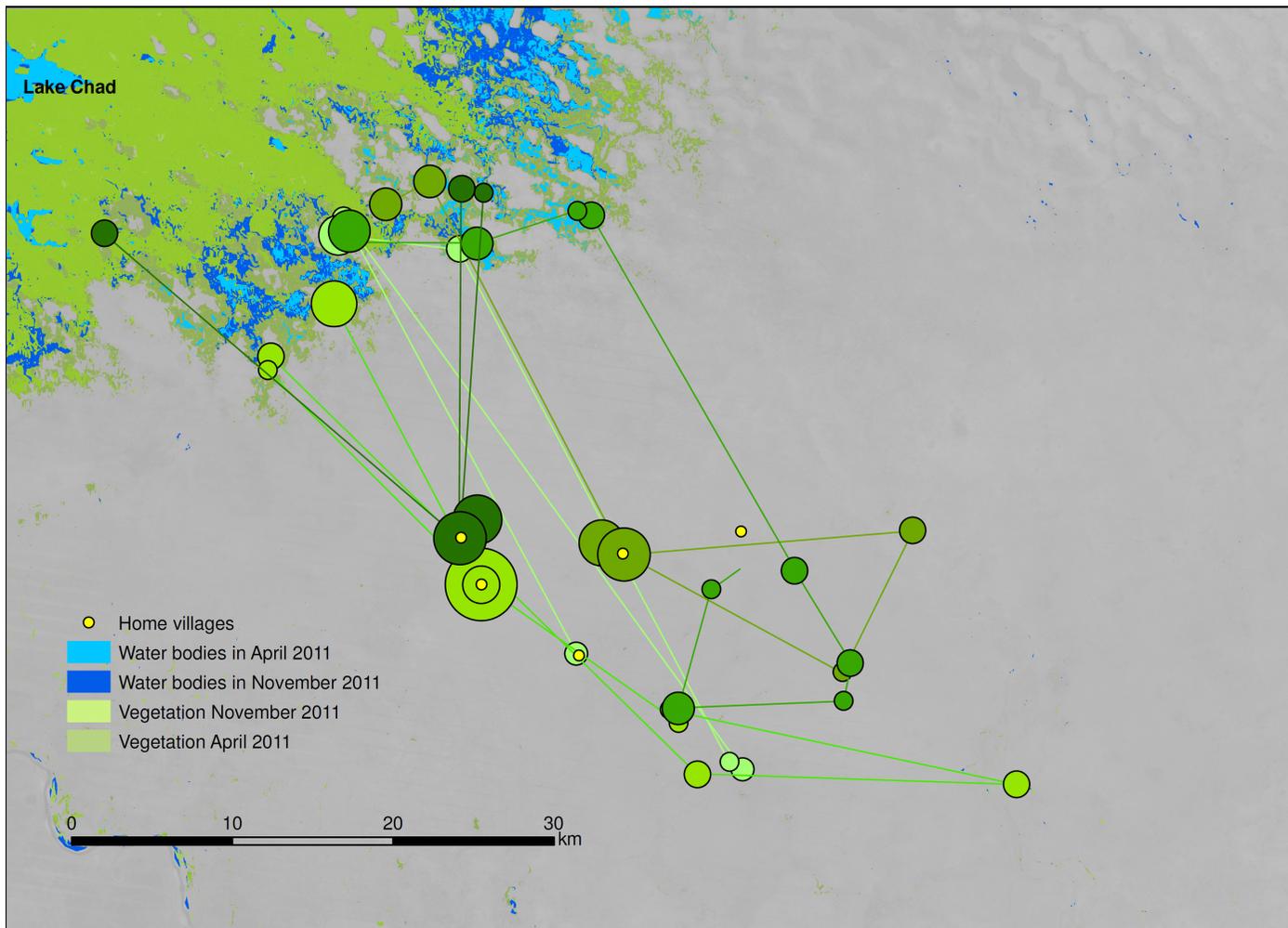


Figure 3.5: Movement of Arab communities in the study zone. Circle size indicates the length of stay in each position. Each colour represents a different community. Yellow points mark position of home villages

Cost-effectiveness of mobile DSS

Based on the actual cost of the small-scale trial, an estimate of the cost for a full scale mobile DSS was prepared. Assuming an effective surveillance of 20,000 mobile pastoralists and 10,000 sedentary dwellers in the same area of the south-eastern shore of Lake Chad, the cost of surveillance is estimated at 13.2 USD per capita in the first year and 10.5 USD per capita in subsequent years. This would include one phone call per month to each participating family and the cost of operating the call centre. The detailed assessment of costs is published elsewhere (35).

3.5 Discussion

The results of the mobile phone surveillance of mobile pastoralists and their herds clearly show the feasibility and advantages of a mobile DSS. The collection of data provided reliable, nearly real-time information on the human and animal population and their movements. No households were lost to follow-up, even though the study spanned 12–18 months and required participants to be available for regular phone interviews. The data were validated internally through a demographic model for the herds and personal contacts for the human population.

The costs for the small-scale study were low since local staff was engaged using locally available resources. The study population is barely accessible due to the remote location and their mobility. In this regard, a mobile phone system appears to be both adequate and cost-effective. The estimated costs of 13.2 USD per capita for the first year and 10.5 USD per capita for subsequent years would include 12 rounds of follow-up per year, compared to 4.17 USD per capita per year for three rounds of follow-up assumed by INDEPTH sites (36). Even the higher first year cost of the proposed mobile DSS is more cost-effective, especially when considering access for remote mobile and settled populations,

the added animal demography aspect and the included emergency health system.

The geospatial analysis reveals different husbandry practices and mobility patterns for the different ethnic groups, confirming the reported disparities of preferential location in close proximity to open water for Foulbé people and in drier areas for Gorane people. It also documents the practise of moving towards Lake Chad for Arab semi-nomadic communities when the pastures around their villages are depleted. These differences are important considerations for future conceptual planning.

Although this study was designed to demonstrate proof of method, rather than to provide demographic results, nonetheless, this information could be used to develop adapted contextual interventions for health and other social services. Information on movements were collected on a close to real-time basis, which provides an opportunity for specific measures and maximises the spatio-temporal accessibility of the camps for social service providers, for instance, aiming to increase coverage of interventions.

The cohort of this study consisted mainly of mobile communities who had previously experienced contact with researchers (17). They were motivated to participate, but this may not always be the case for randomly selected participants of other regions. However, it must be noted that information about this project spread within mobile pastoralist networks, and there was high interest of non-participating camps seeking to participate.

None of the children from the participating households in this study attended a formal school. In explanation, it was often stated that the children are occupied herding the animals. Conflicts between the settled populations and mobile pastoralists are frequently reported (37, 38). The need to accompany herds more

closely to prevent crop damage from animals has increased as the number of agricultural fields surrounding water points has expanded (35). Child labour in mobile pastoralist societies is an issue, not only preventing children from receiving formal education, but also causing isolation and exposure to dangerous environments (39). In Chad, an average of only 29% of girls and 47% of boys complete primary school (40). This inequitable access of mobile pastoralists should be urgently addressed by the authorities as well as international and national organisations. Demographic surveillance of these populations could provide missing information for policies and planning with more equitable access.

In this study, pregnancies of women were recorded from an early stage, which allowed for the observation of spontaneous abortions. As the loss of unborn children is still culturally a forbidden topic, it is very difficult to collect reliable information retrospectively and such data collection is associated with much effort and time investment (8). Prospectively with mobile phones, we had valuable insight into the pregnancy outcomes, especially because interviews were conducted with short time intervals. The proportion of pregnancies not resulting in live birth is alarmingly high, although the small sample size has to be considered. This warrants further evaluation within the scale-up of a mobile DSS.

The validation of herd data with effective counts is very difficult due to cultural norms, with a real possibility to disrupt the trust relationship between participants and researchers. A systematic approach to animal health could facilitate animal counts if a certain level of trust was established. Complementary, internal questionnaire validation of herd structures and sizes is proposed to increase the reliability of numbers. Marking the animals of the herd owner could be considered in a further study, but even that does not guarantee the completeness of data.

The demographic model for cattle was established to show the consistency of the reported data as a method of validation. Its outcome indicates a herd in recovery,

although the population was too small to provide more specific evidence. Density dependence has not been taken into account to establish the demographic model. The birth rate from the model is comparable to birth rates found previously in African cattle (34). The net change rate represents the natural mortality as well as the off-take and acquisition of animals. From comparable demographic studies, it is assumed that calf mortality in African livestock is between 10 and 20% (below 1 year of age), around 4% for animals between 1 and 2 years and 5% for adult animals (34). The low net change rates for the youngest age group in the demographic model would indicate purchase of young animals. Male animals are often bought for fattening and females for re-stocking. For heifers, the net change rate is negative which indicates substantial acquisition of young females for breeding purposes. This compensates for, and even exceeds, the effect of natural mortality. The same phenomenon was described in Gambia (34). The very high net change rates of bulls, including young bulls, indicate an off-take of animals sold at markets for slaughter.

During the observation period, the animal numbers were clearly increasing. The need for recovery and expansion of herds is consistent with reports from mobile pastoralists of high losses in recent years due to disease and lack of pastures. Nevertheless, the animal density numbers in the area are very high. It is likely that pastoralists apply a form of risk management which maintains high animal numbers, thus exacerbating the problem of decreasing pastoral areas associated with increased small-scale farming. Rising cattle numbers due to altered activities are also mentioned by Wiese in interviews with nomadic pastoralist representatives at local markets (11).

The observation period during this study was quite short and the cattle cohort was relatively small to calculate a solid demographic model for people and animals. More meaningful data should be collected with a long-term full-scale mobile DSS. The demographic data collected on livestock, in addition to the data

on humans, shows the potential for a 'one health' demographic and health surveillance system for humans and animals. This would clearly have an added value compared to separate surveillance systems with regard to cost and disease information, especially for zoonotic diseases (41).

We recommend expanding this small-scale survey to a cohort of approximately 20,000 participants and their animals. Continued technological developments should allow for GPS tracking of communities and also the use of applications for disease surveillance, even for illiterate people, in the future. Our experiences strongly support the feasibility of a large-scale project which would likely be low-cost, well accepted by the target population and able to provide reliable real-time data. A longer-term mobile demographic health and surveillance system would have benefits in many diverse areas. Health and demographic data could be collected, along with environmental information about rainfall, droughts and locust infestations and economic information such as prices of cereal, milk and livestock. The real-time knowledge on camp locations and populations would facilitate health interventions such as vaccination delivery or sensitisation and information campaigns. Through the emergency medical and veterinary service, an on-going relationship was maintained with the study population. This personal contact built trust between survey staff and participants in addition to enhancing physical validation of telephone interview data. A sustainable emergency health system utilising shared costs, such as the one developed during this study, would be greatly valued by the local populations. Additionally, outbreaks of human and animal diseases, like cholera, measles or anthrax, could be monitored closely, enabling control measures to be quickly implemented. The combined health, ecological and economic information could be processed into an early warning system for humanitarian crisis situations, which occur regularly in the area, thereby facilitating a timely response.

Conclusion

Mobile phone demographic surveillance of mobile pastoralists and their herds is feasible. This study was limited by its small scale. An extrapolation of the cost per capita for 30,000 fully or partially mobile people in a nearly inaccessible area appears to be more cost-effective than existing DSS (36). A close follow-up of the transhumance patterns could inform health planners on optimal timing and location of preventive interventions to maximise coverage with scarce resources. Near real-time follow-up of pregnancies or other health indicators could allow for the identification of emerging problems more quickly and probably more accurately than through the current official reporting systems. The proposed mobile DSS system could be used for simultaneous health and demographic surveillance of humans and their livestock.

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Conflict of interest and funding

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Chapter 4

Costing analysis for full mobile DSS in Lake Chad area
involving 20'000 mobile pastoralists and 10'000 people from
sedentary communitites

Working paper

4.1 Idea

The small scale study described in Chapter 3 showed the feasibility to practice health and demographic surveillance for mobile communities with an integrated approach at surveillance of their herds using mobile phones and a personal relation of trust. How would it be possible to transfer this knowledge and experience to a larger sized mobile health and demographic surveillance system?

Such a system is desirable because despite all efforts we know very little about mobile pastoralists in the area. The demographic surveillance sites of the INDEPTH-network include communities in different regions and societies, but until now there has never been a mobile surveillance site due to obvious logistical constraints.

Also, it is reasonable to further develop and make use of the longstanding trustful relationship between researchers and mobile populations in Lake Chad area.

A scaling up would generate valuable information but could also serve as a vehicle to implement interventions and to improve the livelihood of mobile pastoralists (i.e. booster vaccinations for childhood vaccinations). Apart from data on demography, the surveillance system could also serve as a vehicle to collect data on other subjects, environmental or economic data such as market prices for milk, cereals, animals or data on flooding, locusts, swarming birds or drought periods. With a comprehensive system, indicators for food crisis, disease outbreaks or other disasters could be identified and an early warning system for humanitarian crises could be developed. Additionally, a surveillance system could facilitate the delivery or monitoring of services such as schooling, civil registration, health and veterinary interventions and others.

For the establishment of a large scale surveillance system we envision to collaborate with existing projects for telemedicine. Chad has joined the RAFT-network (*Réseau en Afrique Francophone pour la Télémédecine*), which was developed by the Geneva University Hospitals (HUG) and partners, and in 2013 the first sites (Abéché, Am-timan, Mao and Pala) will be connected via satellite

connection. Although RAFT is mainly focused on the training of health staff, it also provides teleconsultations and aims to include registration services and even activities in the area of primary education enrolment. An idea for collaboration would be to develop the regional hospital of Massakory as a RAFT site. Or to establish mHealth, which is a mobile phone connection between health centres and the regional hospital (in our case it could also be between mobile pastoralist camps and health centres).

This Chapter proposes a scaling up of the abovementioned small-scale study and develops an analysis of the costs of such a full scale mobile DSS. The accompanying measures as the emergency services for people and animals would be kept up. The target number of mobile participants would be around 20'000 people. Additional to the mobile participants, we would like to include about 10'000 sedentary people from small rural communities to collect comprehensive data.

The conditions for the feasibility include sufficient network coverage for mobile phones and minimal political stability. The interviewers should originate from the area or at least be well acquainted with the communities and speak their language. The call centre would have to be inside the study area to ensure approachability and proximity to the participants.

The costs would be about CHF 12.3 (13.2 US\$) in the first year and below 10 CHF (10.5 US\$) in the following years. We propose one phone call per month, to stay in constant contact and to record transhumance routes. Other INDEPTH sites assume costs of 4.17 US\$ per year per capita for three rounds of follow up per year (Ye et al. 2012). Compared to this, the proposed mHDSS would be in the frame of costs of a INDEPTH HDSS, if the 12 rounds of follow up per year, the animal demography aspect and the included emergency systems are taken into account.

4.2 Budget items

Staff

- At least one coordinator would need to be present in the area to coordinate the interviewers and health staff and to transfer datasets to N'Djamena
- One coordinator in the capital would have to keep in contact with the INDEPTH and RAFT networks and coordinate research activities as well as data storage in N'Djamena
- A health staff like a fully trained nurse should be at the disposal of the team to conduct emergency care for the participants and to visit pregnant women (ante-natal care) and administer pregnancy tests, and also to conduct control visits (full time)
- A veterinary staff would need to be available in case of veterinary emergencies (not necessarily full time).
- One interviewer took about 4 days to conduct 20 interviews, covering about 600 people. Assuming one interview per month with each participant there would be need for 15 interviewers (full time employed) to achieve the target cohort size of 30'000 people.
- One person with excellent local geographic knowledge would have to be employed to record the movement of the camps and transfer it into a GIS program
- One computer specialist would be responsible for data storage, cleaning and back-up

Mobile phones

- Phones for participants who did not own any before the surveillance starts, replacements of batteries, phones etc.
- Transfer of credit after each interview
- Costs of phone calls for interviewers phones

Other expenses

- The interviewers would have to be trained in the use of computers and regular trainings for updates would have to be conducted. Also, the GIS-staff would have to be trained and equipped
- Interventions as pregnancy tests and the transport of health staff to the communities
- A building would have to be rented to host the interviewers and the infrastructure (generator and fuel included)

Reference

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Chapter 4: Costing analysis for full mobile DSS in Lake Chad area
100

4.3 Proposed budget

Proposed budget for full mobile DSS in south-easter Lake Chad area								
Description	Unit	year 1			further years			
		number of units	cost per unit	costs CFA	number of units	cost per unit	costs CFA	
Personnel N'Djaména								
One person 50%	month	12	200'000	2'400'000	12	200'000	2'400'000	
Travel costs	month	12	50'000	600'000	12	50'000	600'000	
Total personnel N'Djaména				3'000'000			3'000'000	
Personnel Grédaya								
Coordinator (full time)	month	12	300'000	3'600'000	12	300'000	3'600'000	
Travel expenses								
Interviewer 1 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 2 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 3 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 4 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 5 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 6 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 7 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 8 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 9 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 10 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 11 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 12 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 13 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 14 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
Interviewer 15 (full time)	month	12	200'000	2'400'000	12	200'000	2'400'000	
GIS staff /controller (full time)	month	12	300'000	3'600'000	12	300'000	3'600'000	
Travel expenses GIS	month	12	100'000	1'200'000	12	100'000	1'200'000	
Nurse (full time)	month	12	300'000	3'600'000	12	300'000	3'600'000	
Travel expenses nurse	month	12	100'000	1'200'000	12	100'000	1'200'000	
Vet staff (part time)	month	12	75'000	900'000	12	75'000	900'000	
Travel expenses vet	month	12	25'000	300'000	12	25'000	300'000	
Computer specialist (full time)	month	12	300'000	3'600'000	12	300'000	3'600'000	
Travel expenses c.s.	month	12	100'000	1'200'000	12	100'000	1'200'000	
Training of interviewers	person	15	200'000	3'000'000	5	200'000	1'000'000	
Recruitment costs	person	15	200'000	3'000'000	5	200'000	1'000'000	
Total personnel Grédaya				61'200'000			57'200'000	
Equipment								
Computers of interviewers	person	15	300'000	4'500'000	7	300'000	2'100'000	
Phones and maint. for interviewers	person	15	20'000	300'000	7	20'000	140'000	
Phones/chargers for participants	participant	1'250	20'000	25'000'000	300	20'000	6'000'000	
GPS for mobile DSS	item	1	200'000	200'000	1	50'000	50'000	
External harddrives, USBs etc	flat	1	500'000	500'000	1	100'000	100'000	
Mapping programs and material	flat	1	500'000	500'000	1	100'000	100'000	
Total equipment				31'000'000			8'490'000	
Crédit								
Transfer for participants	month	12	1'250'000	15'000'000	12	1'250'000	15'000'000	
Crédit to conduct interviews	month	12	3'000'000	36'000'000	12	3'000'000	36'000'000	
Total credit				51'000'000			51'000'000	
Running costs								
Communication, copies	month	12	200'000	2'400'000	12	200'000	2'400'000	
Rent of building, generator, fuel	month	12	200'000	2'400'000	12	200'000	2'400'000	
Tables, printers	flat	1	300'000	300'000	1	200'000	200'000	
Pregnancy tests	item	4'000	3'000	12'000'000	2'000	3'000	6'000'000	
Total running costs				17'100'000			11'000'000	
Overheads CSSI				21'229'000			16'989'700	
Total year				184'529'000			147'679'700	
CHF				369'058			295'359	

Chapter 5

Prevalence of *Fasciola gigantica* infection in slaughtered animals in southeastern Lake Chad area in relation to husbandry practices

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5.1 Abstract

Background

Fasciolosis has been described in sub-Saharan Africa in many accounts, but the latest reports from Chad are from the 1970s. Mobile pastoralists perceive liver parasites as a significant problem and think that proximity to Lake Chad can lead to infection. This study aimed to assess the importance of liver fluke infections in mobile pastoralists' livestock in the south-eastern Lake Chad region.

In 2011, all animals presented at three slaughter slabs near Gredaya in the south-eastern Lake Chad area were examined for infection with *Fasciola* spp. during routine meat inspections.

Results

This study included 616 goats, 132 sheep and 130 cattle. The prevalence of adult *Fasciola gigantica* was 68% (CI 60-76%) in cattle, 12% (CI 10-16%) in goats and 23% (CI 16-30%) in sheep. From all infected animals ($n = 200$), 53% ($n = 106$) were classified as lightly infected with 1-10 parasites, 18% ($n = 36$) as moderately infected with 11-100 parasites and 29% ($n = 58$) as heavily infected with more than 100 parasites per animal.

Animals grazing close to the shores of Lake Chad had a much higher risk of infection (prevalence = 38%; $n = 329$) than animals not feeding at the lake ($n = 353$), with only one goat being positive (prevalence = 0.28%).

The ethnic group of the owner was a strong determinant for the risk of infection. Ethnic group likely served as a proxy for husbandry practices. Geospatial distribution showed that animals originating from areas close to the lake were more likely to be infected with *F. gigantica* than those from more distant areas.

Conclusions

Livestock belonging to ethnic groups which traditionally stay near surface water, and which were reported to feed near Lake Chad, have a high risk of infection

with *F. gigantica*. Pastoralist perception of fasciolosis as a priority health problem was confirmed.

Regular preventive and post-exposure treatment is recommended for animals grazing near the lake. However, further economic analysis is needed.

Keywords:

Fasciolosis; Lake Chad; Mobile pastoralists; Slaughter slabs

5.2 Background

Fasciolosis is a parasitic disease of herbivorous mammals caused by trematodes of the genus *Fasciola*. In livestock, it causes severe reductions in milk and meat yield as well as losses due to decreased fertility [1,2]. The host animals become infected with *Fasciola metacercariae* when they ingest contaminated vegetation close to or within water bodies. Swamp areas and seasonally flooded areas at the borders of Lake Chad provide an optimal habitat for the parasites and the intermediate hosts, which are freshwater snails of the family Lymnaeidae.

In sub-Saharan Africa, infections with *Fasciola gigantica* have often been described [2-5]. In the Lake Chad area, two previous studies from Niger and Cameroon [6,7] have described the disease, but there is no publication from the Chadian side of the lake. *Fasciola gigantica* has been reported in Chadian cattle and small ruminants in a Central African study of wild ruminants [8] and in a treatment study on Chadian cattle [9]. *Fasciola hepatica* infection has not been reported in Chad.

Fasciolosis is perceived as a significant animal health problem by the mobile pastoralist population in the south-eastern Lake Chad area, particularly since other diseases like bovine pleuropneumonia, against which vaccination is

compulsory, are better controlled. Most pastoralist camp leaders expressed concerns about their animals grazing on contaminated pastures in close proximity to water bodies of Lake Chad during a participatory research needs assessment [10]. Some pastoralists are aware that it is possible to treat animals for liver flukes with anti-parasitic drugs, but access to quality drugs is difficult in the remote zones [11].

The majority of the income for mobile pastoralists in this area is generated by selling milk and animals at local markets [12], so the adverse economic impact of fasciolosis is of primary importance. The mobile pastoralists observe the parasites when they slaughter animals and are aware that this is a cause of reduced milk production and body weight. This study was initiated to investigate the mobile pastoralists' priority concern of fasciolosis in their livestock.

5.3 Methods

Study zone and population

The south-eastern Lake Chad area is densely populated by sedentary people as well as by mobile communities of different ethnic groups during the dry season, from October to June. In this paper, we describe the ethnic groups using the names as given by the local communities. Kanembou are mainly sedentary, while Arabs are semi-nomadic, moving towards the lake at the end of the dry season when pasture becomes scarce around their villages. Peul and Gorane communities may be mobile or sedentary, although most large-scale cattle owners are mobile, including the entire family and all of their livestock. Peul is synonymous with the term Foulbe and Fulani (English). Peul herders graze their animals in close proximity to the lake shore, with the animals often feeding on grass in shallow water. The Kouri pastoralists utilise pasture areas that partially overlap with the Peul, primarily herding their cattle on accessible islands within Lake Chad. In contrast, Gorane do not stay close to the lake, instead capitalising on highly developed well building skills for access to water.

Sampling strategy

Each week from January to December 2011, the livers of all slaughtered animals were examined for the presence of *Fasciola* spp during routine meat inspections at three slaughter slabs (Gredaya, Sidje and Bache Djani) in the administrative district of Gredaya at the south-eastern border of Lake Chad. The parasite burden was established by incising the liver along the bile ducts, according to the usual local meat inspection process. No further pathological assessment was made as the study took place during routine meat inspection by the local veterinary delegate. A semi-quantitative estimation of the number of flukes was made based on the number of parasites counted in the exposed surfaces. Infection was classified as being light (1-10 flukes), moderate (11-100) or heavy (>100) in intensity. Most of the off-take from the local herds was animals which were slaughtered and sold at the weekly markets in Gredaya, Sidje and Bache Djani, and all of these were included in the study. Animals slaughtered in households were not examined. The number of examined animals varied from 1-22 per day of observation. The veterinarian interviewed the owner of each animal presented for slaughter, completing a short questionnaire. Information included the origin of the animal, ethnic group of the current owner, animal breed, history of the animal grazing in or in close proximity to Lake Chad and the semi-quantitative level of flukes counted in the liver.

Morphological analysis and measurement of a subsample of the individual fluke specimens collected from infected animals (Figure 5.1) was performed at the Laboratoire de Recherches Vétérinaires et Zootechniques in Chad, based on descriptive criteria [13-15], including body size and shape, form of the apical cone and position of the suction cups and ovaries.



Figure 5.1: Sample of *Fasciola gigantica* from cattle from southeastern Lake Chad area

The data were double entered in Microsoft® Access 2002 (Microsoft Corp.; Redmond, WA, USA), and compared using Epi Info™ 3.5.1 Data Compare program (Centers for Disease Control and Prevention, Atlanta, GA, USA). Statistical analysis using descriptive statistics and logistic regression was conducted with Stata IC 10.1 (StataCorp LP, College Station, USA). ArcGIS 9.3 (ESRI Inc. ArcMap™ 9.3, Redlands, CA, USA) and Google Earth (Google Inc., Mountain View, CA, USA) were used for mapping and spatial analysis.

5.4 Results

A total of 880 animals were examined. Two animals were excluded because questionnaires were not completed. Data from the remaining 130 cows, 616 goats and 132 sheep were analysed. The distribution of livestock species by owner ethnic group is shown in Table 5.1.

Table 5.1. Sample size of species and ethnic groups of the owners

	n	%	Arab	%	Peul	%	Gorane	%	Kanembou	%	Kouri	%
Cattle	130	15%	10	8%	85	65%	28	22%	1	1%	6	5%
Goats	616	70%	278	45%	133	22%	133	22%	72	12%	0	0%
Sheep	132	15%	27	20%	56	42%	47	36%	2	2%	0	0%
Total	878	100%	317	36%	274	31%	208	24%	75	9%	6	1%

Fasciola gigantica specimens (n = 11) measured between 2 and 5 cm, with a mean size of 3.2 cm.

The prevalence of *F. gigantica* was 68% (95% CI 60-76%) in cattle, 12% (95% CI 10-16%) for goats and 23% (95% CI 16-30%) for sheep. The analysis revealed a strong relationship ($p < 0.001$) between grazing at the lake and *F. gigantica* infection. Not feeding at the lake was a protective factor, and only one animal reported as not grazing near the lake was infected with *F. gigantica* (0.28%) (Table 5.2.)

Table 5.2. Prevalence for infections with *F. gigantica* by species and stratified for grazing area

	Grazing	LC	pos	%	neg	%	Total	Prev	p	OR	CI (95%)
All animals	yes	198	38%	329	62%	527	22.6%	<0.001	212	29.5-1520	
	no	1	0%	352	100%	353			Baseline		
Cattle	yes	89	93%	7	7%	96	68.5%		n.a. perfect prediction		
	no	0	0%	34	100%	34					
Goats	yes	79	22%	277	78%	356	13.0%	<0.001	74	10.2-534.6	
	no	1	0%	259	100%	260			Baseline		
Sheep	yes	30	41%	43	59%	73	22.7%		n.a. perfect prediction		
	no	0	0%	59	100%	59					

The highest prevalence was seen in cattle from the Kouri ethnic group (100%, n = 6), and livestock owned by Peul also showed high prevalence (95% for cattle, 33% for goats, 48% for sheep). None of the Gorane cattle were reported to have grazed in the lake, and none were positive for *F. gigantica*. Of all Gorane animals (n = 208), only one goat was infected with *F. gigantica*. There was no infection with *F. gigantica* in animals from Kanembou breeders (n = 75). The prevalence in Arab livestock (13%, n = 317) ranged in between those grazing near lake water and those not near the lake (Table 5.3.).

Table 5.3. Prevalence of *F. gigantica* in different livestock species by ethnic group of the owner

	Ethnic group	pos	%	neg	%	Total	p	OR	CI (95%)
	Gorane	1	0%	207	100%	208	0.001	0.03	0-0.2
	Peul	152	55%	122	45%	274	<0.001	8.6	5.7-12.9
	Arab	40	13%	277	87%	317		Baseline	
	Kanembou	0	0%	75	100%	75	n.a.	perfect prediction	
	Kouri	6	100%	0	0%	6	n.a.	perfect prediction	
	Gorane	0	0%	28	100%	28	n.a.	perfect prediction	
	Peul	81	95%	4	5%	85	<0.001	81	12.8-513.2
Cattle	Arab	2	20%	8	80%	10		Baseline	
	Kanembou	0	0%	1	100%	1	n.a.	perfect prediction	
	Kouri	6	100%	0	0%	6	n.a.	perfect prediction	
	Gorane	1	1%	132	99%	133	0.04	0.05	0-0.4
	Peulh	44	33%	89	67%	133	<0.001	3.4	2.1-5.7
Goats	Arab	35	13%	243	87%	278		Baseline	
	Kanembou	0	0%	72	100%	72	n.a.	perfect prediction	
	Gorane	0	0%	47	100%	47	n.a.	perfect prediction	
	Peul	27	48%	29	52%	56	0.003	7.4	2.0-27.6
Sheep	Arab	3	11%	24	89%	27		Baseline	
	Kanembou	0	0%	2	100%	2	n.a.	perfect prediction	

Among all positive animals ($n = 200$), 53% ($n = 106$) were classified as lightly infected (1-10 parasites), 18% ($n = 36$) as moderately infected (11-100 parasites) and 29% ($n = 58$) as heavily infected (> 100 parasites). In cattle, 19% of infections ($n = 17$) were light, 20% ($n = 18$) moderate and 61% ($n = 54$) heavy; in goats, 80% ($n = 65$) were light, 17% ($n = 14$) moderate and 2% ($n = 2$) heavy; and in sheep, 80% ($n = 24$) light, 13% ($n = 4$) moderate and 7% ($n = 2$) heavy. There was a significant difference between the degree of infection in cattle and small ruminants. Sheep and goats had very similar prevalence and burdens.

The prevalence in cattle in Sidje, the slaughter slab closest to Lake Chad, was significantly higher than in Gredaya ($p = 0.003$). Seasonal trends indicate a lower prevalence between the months of August to October, comprising the rainy season, compared to the rest of the year in all species.

Geospatial distribution

The prevalence rates were plotted according to the coordinates of the villages of origin to show the geospatial distribution of animals and the proportion of positive animals. The size of the circle corresponds to the number of animals originating in each village (Figure 5.2 shows the data for goats, data for cattle are shown in Figure 5.3, data for sheep are shown in Figure 5.4. There is a notable relationship between proximity to the lake and infection with *F. gigantica* in all three species.

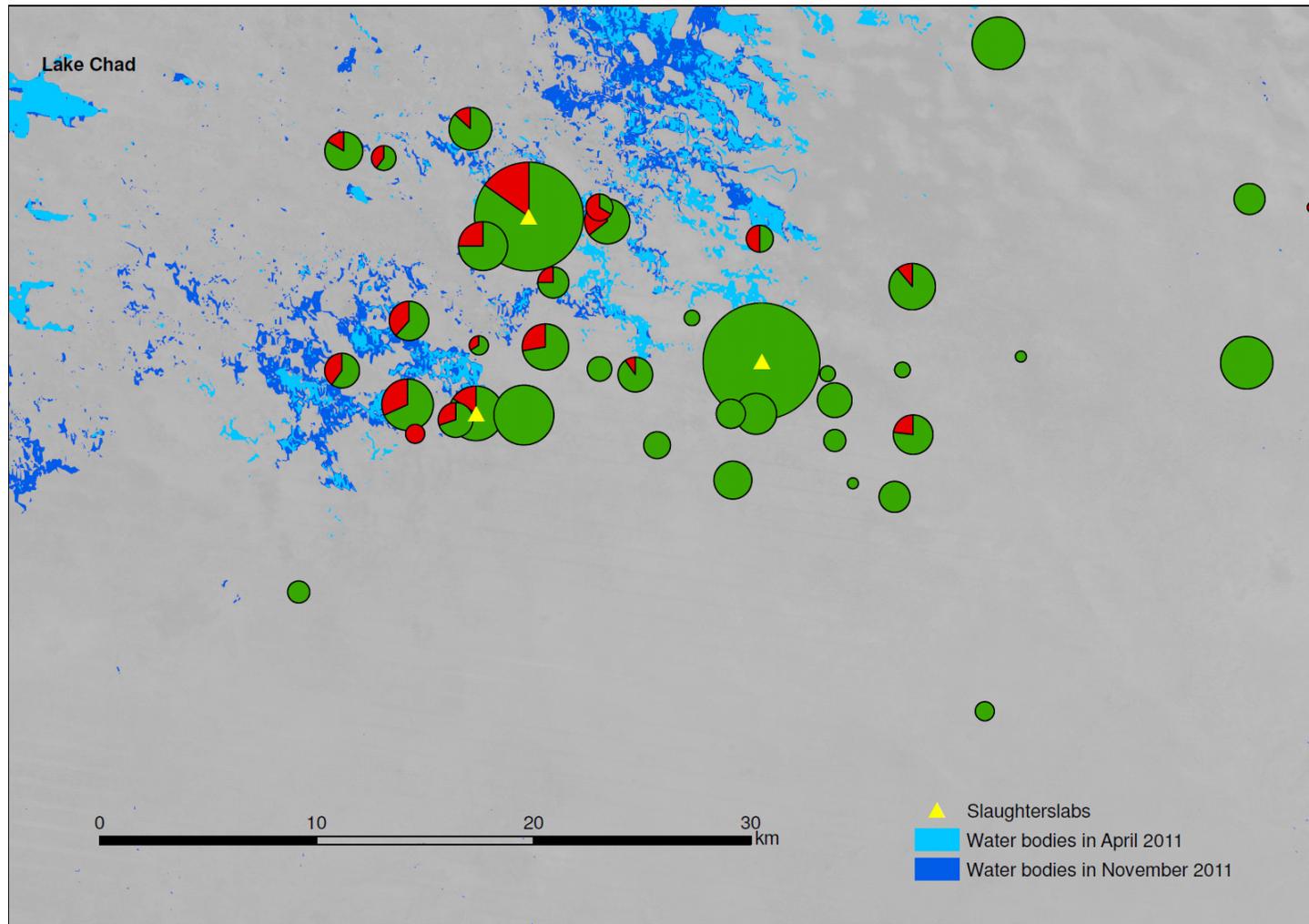


Figure 5.2: Prevalence of *F. gigantica* in slaughtered goats by village of origin. Legend: prevalence rate according to village of origin coordinates, circle size corresponds to the number of animals, red indicates proportion positive for *Fasciola gigantica*.

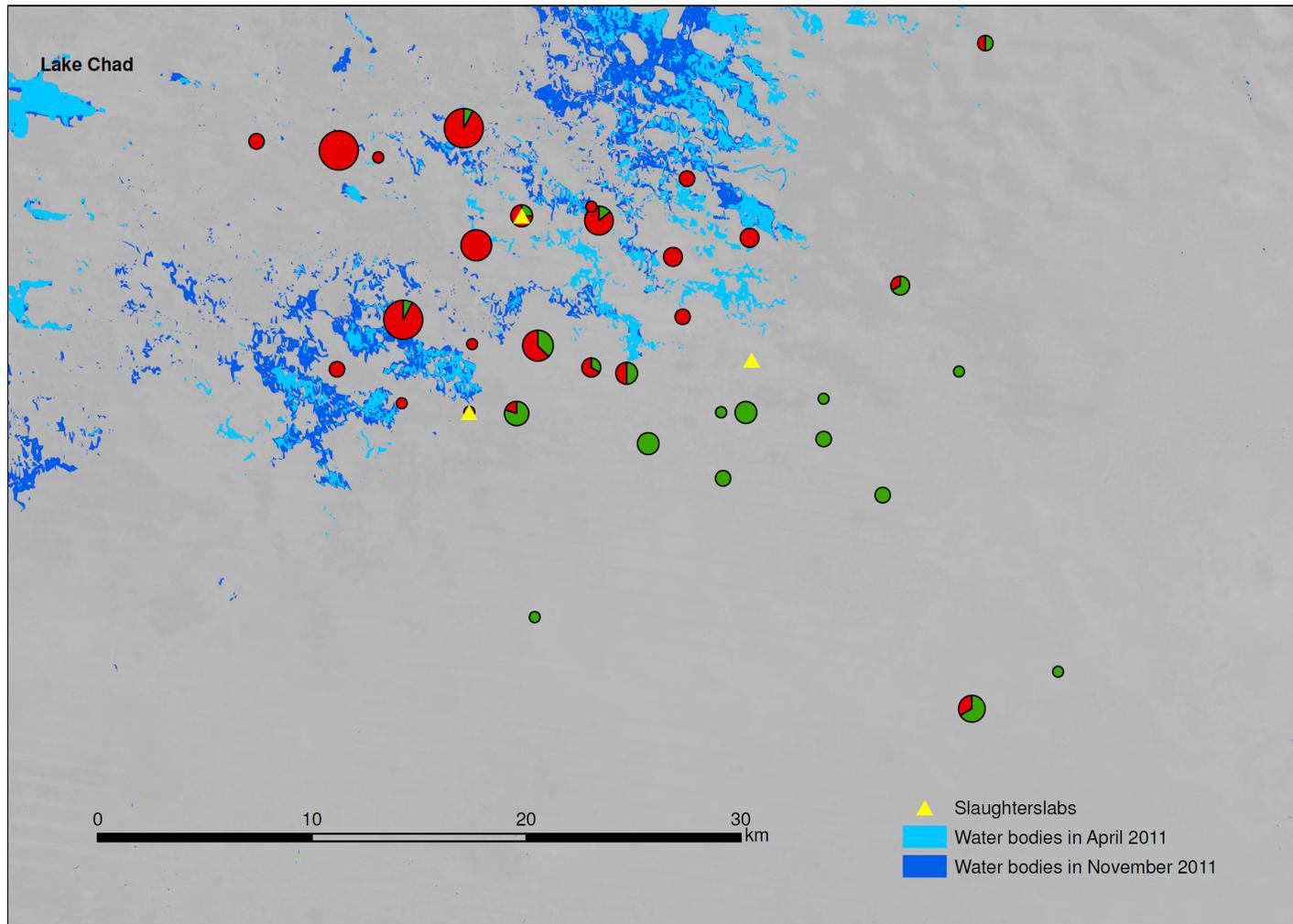


Figure 5.3: Prevalence of *F. gigantica* in slaughtered cattle by village of origin. Legend: prevalence rate according to village of origin coordinates, circle size corresponds to the number of animals, red indicates proportion positive for *Fasciola gigantica*.

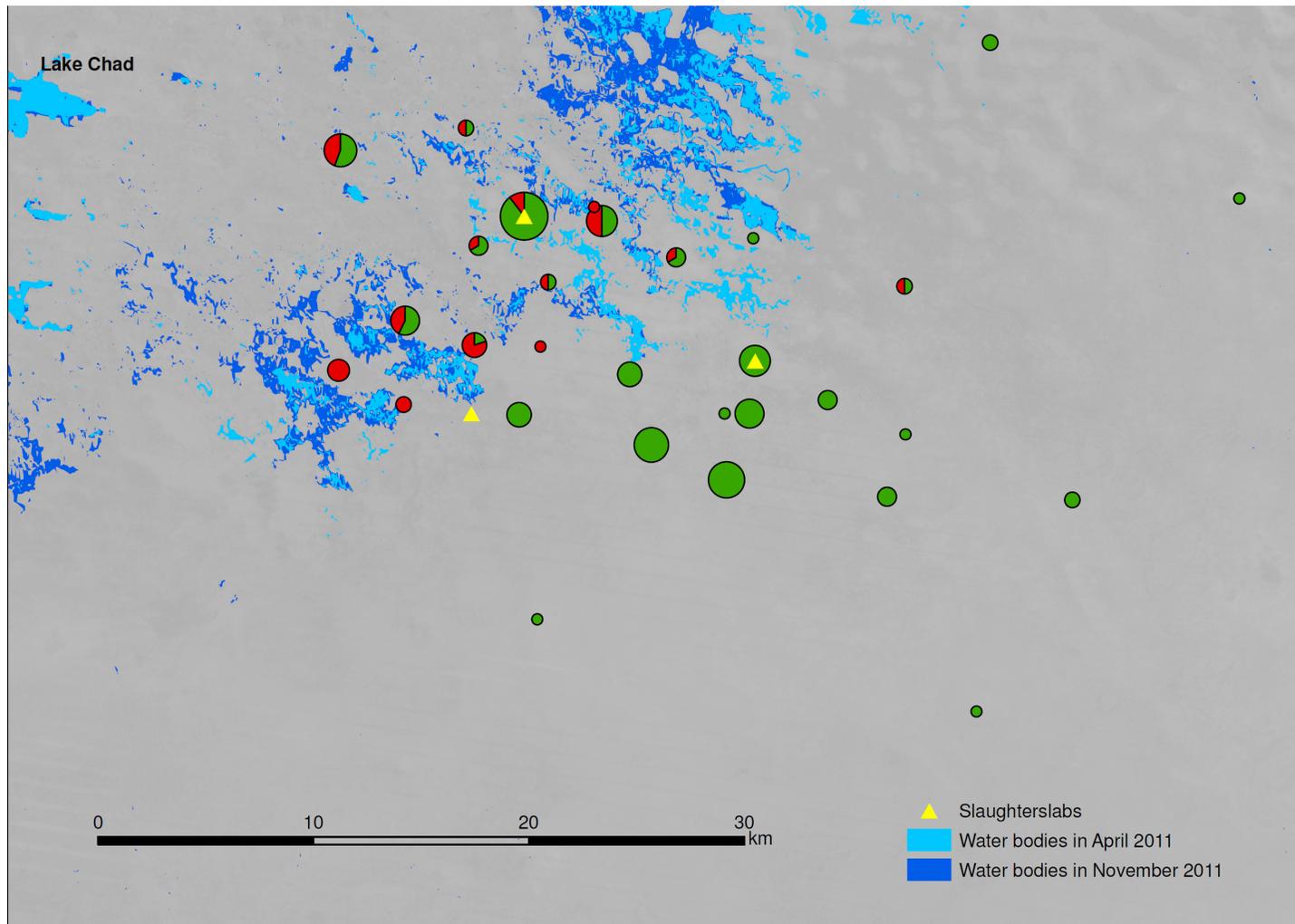


Figure 5.4: Prevalence of *F. gigantica* in slaughtered sheep by village of origin. Legend: prevalence rate according to village of origin coordinates, circle size corresponds to the number of animals, red indicates proportion positive for *Fasciola gigantica*.

5.5 Discussion

This is the first publication on *Fasciola* infection in cattle, sheep and goats in the Lake Chad area of Chad. The results support a relationship between the infection of livestock with *F. gigantica* and the ethnic group of the livestock holder. The ethnic group likely serves as a proxy for the type of animal husbandry practiced [10]. The Kouri cattle, which were kept on islands in the lake, were 100% positive for *F. gigantica*. Although the sample size was very small ($n = 6$), nonetheless there was clearly a high prevalence in these animals. The livestock kept by Peul, who utilise pastures close to the lake and its seasonal extensions, also showed a high prevalence (55% overall, 95% for cattle). In contrast was the low prevalence found in the Gorane and Kanembou livestock. The Gorane pastoralists do not move close to the lake, but stay in drier areas to the east. The Kanembou culture and husbandry practices are, in general, similar to the Gorane, although in the study zone, the majority of Kanembou were sedentary rather than mobile. The prevalence found in Arab livestock ranged in between that found in the other ethnic groups (Kouri/Peul and Gorane/Kanembou). This finding is supported considering that Arab cattle breeders in the zone were semi-nomadic, only moving their animals towards the lake at the end of the dry season, when the pastures around their villages were depleted.

There was a notable relationship between proximity to the lake and infection with *F. gigantica* in all three species. The geospatial distribution and the analysis of grazing patterns strongly suggest that Lake Chad is the source of infection. This would also explain the observed seasonal trend, which is likely due to migration away from the lake during the rainy season when grass is more widely available, potentially reducing exposure to the contaminated areas close to the lake. Further research is currently continuing to establish the seasonal dynamics of *F. gigantica*. The results of this study support a strong recommendation, for Kouri and Peul livestock, for treatment against *F. gigantica* infection with an initial prophylactic dose when entering the lake region and a second dose at the

beginning of the rainy season, or when leaving the area. This type of programme could reduce pasture contamination and the effects on livestock productivity, particularly for Arab livestock that is not continuously grazed near the lake. In contrast, no preventive treatment is necessary for Gorane and Kanembou livestock that are grazed in areas not near the lake. Because they are not in proximity to open water, these animals have a negligible risk of infection. Our recommendation is in line with that of the local veterinarian in the Gredaya administrative district, who recommended treatment every three months as long as animals were kept near the lake.

It was noted that prevalence and degree of infection differ between species. This is likely due to feeding patterns as well as specific husbandry practices. Small ruminants avoid wet areas, instead preferring to graze and browse on dry ground. However, grazing dry pastures is not completely protective, as *Fasciola metacercariae* can remain viable for some time on vegetation and in some of the intermediate host snails of the genus *Lymnaea* in previously flooded areas [13,14]. Pastoralists in the study area reported that they kept their small ruminants away from the more humid areas near the water as long as possible to decrease the risk of infection, as also noted by Tager-Kagan in the 1970s [6].

In this study, sheep and goats had comparable infection intensities. The similar burden in sheep and goats could indicate similar susceptibility to infection and/or result from use of comparable feeding areas. Although sheep commonly graze ground cover, while goats typically browse shrubs and trees, the Lake Chad region is now densely populated with herds and subject to increased agricultural cultivation, so there are relatively few shrubs, particularly at the end of the dry season.

The higher prevalence noted in cattle at the slaughter slab in Sidje is likely because many Peul pastoralists pass by this village when leaving the lake or stay nearby during the rainy season.

In this study, meat inspection was performed according to the routine local inspection procedure, which consisted of one long transverse cut in the liver along the bile ducts. The method of examination was a limitation to this study in that it provided only a semi-quantitative measurement of the parasite burden. While it would have been ideal to examine the entire organ by cutting it into small pieces to visualise all biliary ducts, the cost to purchase every liver precluded such a method. Using the standard meat inspection approach, it is possible that some animals with few parasites might have been misclassified as not infected. Also, particularly in cattle due to the large liver size, multiple incisions might have shown a higher number of parasites. Therefore, the prevalence and degree of *F. gigantica* infection intensity might have been underestimated using the standard, locally available, semi-quantitative evaluation method employed in this study, but the exposure patterns revealed are nonetheless significant and valid, despite a potentially decreased sensitivity of this method.

Although fasciolosis is increasingly being recognised as a human public health issue [15,16], there is very little literature on *F. gigantica* from Chad or the Lake Chad region, with the most recent dating from the late 1970s [6-8]. At that time, the recommended control measure was routine deworming treatment of livestock once or preferably twice per year, before and after the rainy season [6,9]. Based on the results of the present study, this recommendation should still be implemented for herds grazing near Lake Chad. Further cost-benefit analysis is warranted, as findings would provide evidence for information campaigns and policy development. It is also recommended to assess pastoralist's access to and the quality of available treatments for fasciolosis in remote areas.

Conclusions

This research quantifies the prevalence of *F. gigantica* in slaughtered livestock in south-eastern Lake Chad area and provides a semi-quantitative assessment of the burden of infection.

The results showed that animals which had grazed in close proximity to the lake and its seasonal extensions had a high risk of infection. Cattle of Peul and Kouri ethnic groups were most affected. These groups keep their animals at the shore of Lake Chad or on islands within the lake.

The study confirms the pastoralists' perceptions of disease priorities with fasciolosis as an important health problem.

Treatment against fasciolosis is recommended for animals grazing near or at the lake, and further economic analysis of such treatment is warranted.

The data set supporting the results of this article is available online at BMC Veterinary Research

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

VJR supervised data collection in situ, entered and analysed the data and drafted the manuscript. LC contributed to the realisation of the study and drafted the manuscript. AAA assisted with data entry and coordinated the collection and transport of data. NBN and HG participated in the conceptualisation and realisation of the study and contributed expert opinions to the draft. JH provided statistical knowledge and contributed to statistical analysis. ES added expert knowledge from earlier research in the area. JZ engaged in the conceptualisation of the study and gave general supervision throughout the study. All authors read and approved the final manuscript.

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Chapter 6

Short communication

Poultry production in mobile pastoralist' and sedentary communities and reported events of high mortality

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6.1 Abstract

Chicken husbandry can have a great effect on the nutrition and economy of rural communities. Equally, poultry diseases such as Newcastle disease can have a negative impact on their livelihoods. The southeastern Lake Chad area is densely populated by small subsistence-farming villages and there are also a large number of mobile pastoralist communities in the area. Access to food is perceived as a problem to both types of communities.

Data is presented which demonstrates that mobile as well as sedentary communities keep chickens and that they were affected by severe chicken disease outcomes during last years. The data is suggestive of Newcastle disease and thus presents an opportunity to improve local livelihoods by appropriate interventions, as well as to ease the problem of nutrition in the area.

Keywords: Chicken, Lake Chad, mobile pastoralists, mortality

6.2 Introduction and methods

The southeastern Lake area in Chad has become increasingly populated during the last 40 years as the surface of the lake has been receding and revealing very fertile agricultural land on the former lake floor. However, the area is not only populated by agricultural communities in villages, but has traditionally been an area of pastoralism for different ethnic groups whose numbers in the area are also increasing due to drought episodes in other transhumance areas. The zone is receiving food aid from the World Food Program (WFP), although mobile pastoralist communities (and also several small villages) state that they have virtually no access to it due to perceived arbitrariness, political and probably logistical issues (see Chapter 1). During open interviews, 86% (n=75) of the mobile and 74% (n=29) of the sedentary communities spontaneously stated that nutrition and access to food was a problem for them (see Chapter 1).

Poultry husbandry can have a positive impact on the nutrition and economy of rural communities due to low investment costs (Guèye 2000; Alders & Pym 2009), especially where chickens are kept extensively as scavengers (Kitalyi & Nations 1998). Also it has been shown that Newcastle disease (ND) can result in severe economic losses in sub-Saharan Africa and that vaccination against ND can cause a fundamental increase in economic status (Kitalyi & Nations 1998). Newcastle disease is one of two poultry diseases (with highly pathogenic avian influenza) considered important enough to be monitored by REPIMAT (Réseau d'Epidémiologie- Surveillance des Maladies Animales au Tchad) in Chad (MERA 2008).

From November 2010 to April 2012, 133 interviews were conducted with mobile pastoralist and sedentary communities in southeastern Lake Chad area. Usually the community leader participated together with other community members as a group, and answers were discussed between them.

In total, 91 interviews with mobile communities and 42 interviews with sedentary villages were conducted. Information collected included the human population, chicken population and also the occurrence of a chicken disease which killed all chickens during the last year were collected.

The purpose of this short communication is to provide data on chicken populations in mobile communities which are often assumed to not own any chickens and to document a suspected Newcastle disease outbreak in the area.

6.3 Results and discussion

Chicken ownership

The median community size was 157 people (25%-75%: 75-255) with a median number of 80 village chickens per community (25%-75%:16-165) (Figure 6.1).

Chickens are usually owned and tended by women in mobile as well as sedentary communities. The sedentary communities had significantly more chickens ($p < 0.001$) with a median of 200 chicken per community (25%-75%: 100

- 500) compared to a median of only 40 chickens for mobile communities (25%-75%: 10-100). However it is remarkable that mobile communities do keep chickens at all, since they are difficult to care for during transhumance and have to be transported over large distances.

Sedentary people owned significantly more chickens ($p < 0.001$), they reported an average of 1.24 chicken per person (95%CI: 0.75 – 1.74). In contrast, mobile people owned 0.43 (95%CI: 0.34 – 0.52) chicken per person. Nevertheless this can be an important economic factor for mobile communities as well and a substantial contribution to their nutrition. There was no significant difference between the ethnic groups (Peul, Arab and Dazagada).

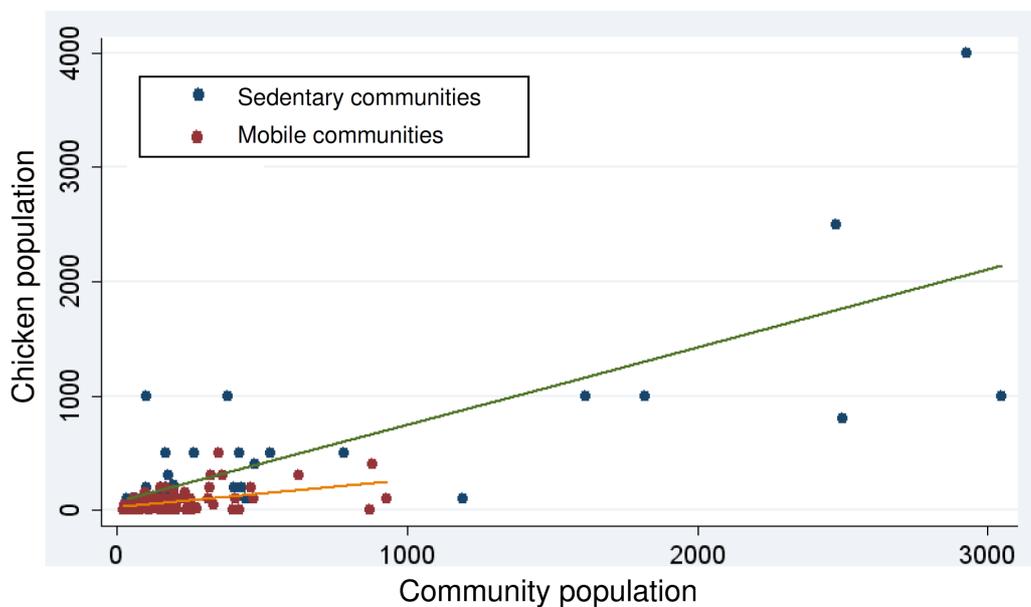


Figure 6.1: Community and chicken populations of sedentary and mobile communities

Reported high chicken mortality

Eighty nine percent of sedentary communities (n=28) reported a disease that killed all their chickens during the last year (n=25). After the disease outbreak, they report to usually started anew with chickens bought from the local market.

Of the mobile communities who owned chicken, 81% (n=63) had experienced 100% mortality in their chickens during the last year. The observed pattern is compatible with Newcastle disease, although no laboratory diagnosis was made (Figure 6.2).

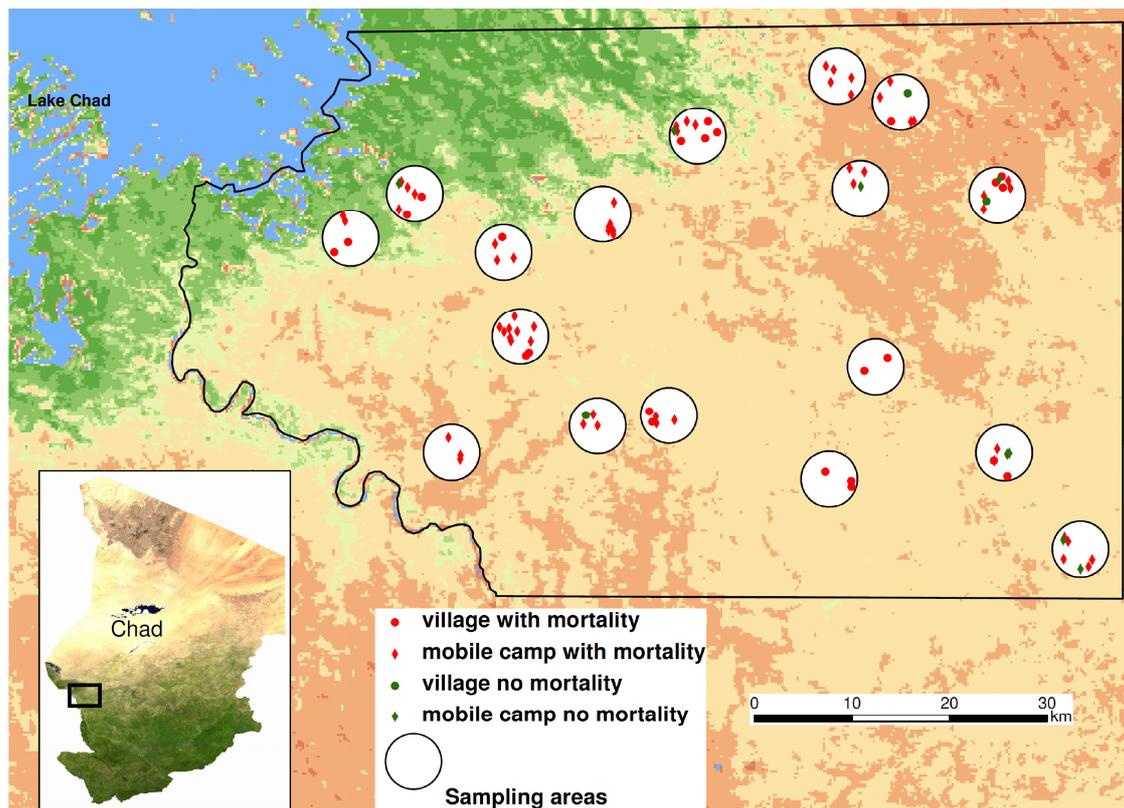


Figure 6.2: Reported total population mortalities in chicken population of mobile pastoralist camps and sedentary villages in the study area between October 2010 and April 2012.

Technically, Newcastle disease vaccine is available at the central veterinary authority office in Karal, but only two of the communities had received poultry vaccination and one additional village had partially vaccinated its poultry.

Veterinary services are not well developed in the area and many communities were not aware of the possibility of vaccinating poultry.

While the disease outbreak reported above was not confirmed in a laboratory, ND is perceived as an issue in Chad and is the only poultry disease apart from highly pathogenic avian influenza that is monitored by the REPIMAT (Réseau

d'Epidémiologie- Surveillance des Maladies Animales au Tchad), the national network for animal disease surveillance in Chad.

Should ND be confirmed, appropriate measures to prevent ND and general husbandry of chickens could be an entry point to improve the economic and nutritional situation of these communities.

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VII. General discussion

In the discussion we concentrate on the strategic planning issues which can be addressed from the results of our work. Methodological issues of our research are discussed separately in each chapter which are presented as separate papers and are not again discussed here.

This thesis shows that low cost human and animal density estimates of sedentary and mobile pastoralists and their livestock are possible with a randomised, GPS-driven surveillance method. The observed densities are above other published information of carrying capacities in similar areas. The social, ecological and economic consequences of this are discussed.

A main achievement is the proof of principle of a mobile health and demographic surveillance system (mHDSS) of mobile pastoralists, using mobile phones and locally acquainted technical. The small scale surveillance system can be scaled up to a full mHDSS, involving 20'000 mobile pastoralists and 10'000 people from rural sedentary communities at the initial costs of 13.2 US\$ per person and year and for each following year below 10.5 US\$ per person and year including additional services. There are also options to extend this mHDSS to cover environmental and economic issues as well as social services like schooling. Findings on perceived livelihood priorities of mobile pastoralists include access to food, animal and human health, access to pastures and water, and education. The concern about access to pastures reflects the observed high density of animals in the area. Human and animal health issues are important but have to be seen in the context of the other ecological, social and political issues of pastoralist livelihoods.

The study on liverfluke infections confirmed the perceived importance of *F. gigantica* infections in livestock by the pastoralists. The animals showed a discreet pattern of infection depending on their exposure to the lake. These observations should serve as a basis for the development of specific control strategies in the area and have led to further, ongoing research.

Based on these main findings, we develop a vision for the scaling up to a full mobile health and demographic surveillance system (mHDSS) and address the development of a regulatory framework for sustainable and equitable land use management. We further discuss the consequences of the epidemiological findings of *F. gigantea* for further research and control. Finally, we discuss potential entry points for development interventions based on the results of the participatory needs assessment.

VIII.1 Visions of a scaling up to a full mobile health and demographic surveillance system (mHDSS)

The proof of principle for mobile demographic and health surveillance provides a basis for a larger scale surveillance system for mobile pastoralist communities (mHDSS). A mHDSS would also include a certain number of sedentary communities from the area who are often facing similar or complementary problems (see Chapter 1). The estimated costs for a mHDSS are below 10 US\$ per participant (see Chapter 4).

However, the proposed system would not only be low-cost, but as it provides almost real-time data and is well accepted in the communities, can also facilitate the implementation of a number of other interventions:

Besides the generation of demographic and health indicators, a mobile health and demographic surveillance system could serve as a vehicle to collect various types of data and to provide diverse services. Outbreaks of epidemics such as cholera, measles and other contagious diseases could be monitored and reacted on in a short time period.

Furthermore, such a system could collaborate and or even be integrated into an existing telemedicine programme such as the RAFT (Réseau en Afrique Francophone pour la Télémédecine), hosted by the Geneva University Hospitals and working with partners such as the Université Numérique Francophone Mondiale (UNFM), the Digital Solidarity Fund (DSF) and the World Health

Organization (WHO). The main focus of the RAFT is the continuous training of health professionals in remote areas, but it also promotes teleconsultations, tele-echography and other services. In Chad, the system is already established, and will be extended to new sites shortly.

Additionally, collaboration with current efforts by the government and NGOs to provide mobile schooling could be envisioned, and the mHDSS could facilitate the monitoring of mobile education. Similarly, the RAFT is planning to monitor primary school enrolment.

A further aspect could be the collection of environmental and economic indicators. Data about rainfall, droughts, locust-invasions, flooding or the state of pastures in combination with the development of prices of milk, meat and cereals could contribute to develop an early warning system for food shortages and humanitarian crisis situations.

VIII.2 Development of a regulatory framework for sustainable and equitable land use management

The density of livestock in the study area is very high during the dry season. Furthermore, the areas used for agriculture are increasing from year to year, aggravating the scarcity of pastures available for mobile pastoralists. This situation can lead to an overuse of pastoral areas, as the increasing spread and dominance of the plant *Calotropis procera* (Sodom apple) already now indicate, a species that is not consumed by ruminants due to toxicity. The human as well as the animal population are expected to continue growing during the next years (Ngounou Ngatcha 2009; MERA 2008). Therefore we expect conflict situations between sedentary and mobile communities to become more abundant and more serious.

The high human and animal densities in the area call for an improved framework to regulate access and use of natural resources. Several authors have emphasized the importance of a new legal framework recognising the

overlapping systems of sedentary and mobile communities. The aim is to regulate the legitimacy of each group's claims taking into account the highly political aspects (Montavon et al. 2013; Bechir 2010; Hatfield & Davies 2006; Fokou et al. 2004; Scoones & Graham 1994).

To develop a new framework, it is essential to involve all stakeholders in a process of active dialogue. Condition to that is an organisational structure that legitimately represents the interests of mobile communities. Attempts to organise the mobile communities into an interest group are being made at the moment in Chad by the "Association des Jeunes Nomades" who lobby on local as well as national levels and provide services like legal advice for conflicts between pastoralists and farmers.

IUCN has analysed the institutional and legal situation in several countries around Lake Chad, including Chad, with regards to strategically react to the drastic decline of open water surface of the lake and its implications for the population. The report states that the main difficulties for the realisation of initiatives are: the late involvement of the livestock production sector in planning, the lack of documentation and outdated regulations, political instability, failure of consensus, little involvement of the local population and community participation and financial constraints as well as inappropriate management of budgetary allocations.

At the moment several legal regulations are in place for natural resource management:

- for mobile pastoralism on Chadian territory from 1959
- three decrees about land use management from 1967
- a water management regulation from 1999 and
- a regulation concerning the environment from 1998

Although especially the first two regulations are outdated and do not reflect the actual context anymore, they are still legally valid (IUCN 2011).

During the last 15 years, a process for a new regulation framework for pastoralists ("*Code Pastoral*") has been evolving in Chad. In 1999, the revision of

the ancient law from 1959 which regulates nomadism, was formally recommended by the national seminar on conflicts between farmers and pastoralists. It was taken up by the Ministry of Livestock (at that time: *Ministère d'Élevage*) and the “*Collectif des Associations des éleveurs nomades*”. This initiative ended 2002 by the proposition of a pre-project, which would have had to be adopted by the national assembly. Before that could happen, the project was harshly criticised for being too hasty made and for not addressing crucial points at a workshop involving participants from many stakeholder groups and was therefore finally abandoned.

From then the efforts concentrated on the development of a regulation framework for pastoralists (“*Code Pastoral*”) with the support of the *Ministère de l'Élevage et des Ressources Animales* (MERA). An agreement between the MERA and pastoralist groups had been signed in 2002. A national workshop was conducted in 2005 to create tools to promote pastoral development in Chad. Many of its recommendations have then been taken into account (as primary priority the elaboration of a *Code Pastoral*) for the Plan National de Développement de l'Élevage (PNDE), validated by MERA in 2008.

The process for the development of a Code Pastoral has gained new momentum with the involvement of the FAO in 2007 but progress was still slow. Another national workshop was held in Mars 2011, and a pre-project to test new regulations was launched as well as further research initialised (Alfaroukh et al. 2011).

Since then, slow progress has been made, resulting in the creation of a direction of health of mobile pastoralists within the Ministry of Health in 2013 and the taking up of an intersectorial project by several ministries. The impacts of these efforts on the community level are minimal, though, if they are noticeable at all. Further lobbying and support from the concerned population as well as from national and international actors is still needed to achieve tangible results for equitable rights, land use management, the provision of health and veterinary services and schooling.

VIII.3 Fasciola treatment and prevention

Many representatives of mobile communities, but also of sedentary villages mentioned that their animals were infected with whitish parasites in the livers, which indicated infection with liverflukes (*Fasciola gigantica*). This seemed to be a concern to local people, as it affected not only animal health, but also household economy and nutrition (see Chapters 1 and 5). Therefore we decided to investigate further and generate evidence about the intensity of these infections, the prevalence in different livestock species as well as the spatial dimension of infection, as corresponds to objective III.

Livestock has been shown to get infected with *F. gigantica* when grazing close to water bodies of Lake Chad. The transmission of the *F. gigantica* close to open water is no novelty, although it has never been described in this particular area, except, reportedly, in technical reports of the Laboratoire de Recherches Vétérinaires et Zootechniques in N'Djamena (LRVZ). Mobile pastoralists are well aware of the risk at close proximity to the lake. Arab pastoralists only move towards the lake if there is no other possibility, when all other accessible pasture areas depleted.

The livestock owners are also well aware of the treatment against infections with Fasciola. The same treatment, Triclabendazole, is in use since 1983 and is nowadays available as many generic products. The Chadian local veterinarian responsible for the zone recommends treatment for all animals every three months as long as they are feeding in close proximity to the lake. However, the quality of the available treatment remains an issue in the study area, as mobile pastoralists report the available drugs as being ineffective. The drugs are usually bought on the market from mobile drug sellers who often import their medications from Nigeria. These drugs are much cheaper and easier accessible than drugs available in veterinary pharmacies in the capital N'Djamena. The quality and origin of drugs sold on local markets should be analysed in a next step to develop realisable recommendations and measures for treatment.

Furthermore, pastoralists often treat only those animals which are visibly sick or weak. This leads to a continuous contamination of pastures and water bodies by animals with lighter infections that don't show any symptoms.

An interruption of the transmission would only be possible with mass administration of treatment. The economic efficiency of such an intervention would have to be shown prior to administration. The access to the herds for veterinarians is complicated by their mobility and unpredictable length of stay in one location. Furthermore, the lack of roads and irregular flooding would have to be considered for logistical planning of mass treatment administrations. The compliance of the herd owners could also be an issue, as negative experiences in the past and persistent rumours of negative effects of vaccinations and drugs could provoke them to only treat part of their animals.

Further research on the intermediate hosts and on human and animal infection with *Fasciola* and *Schistosoma* is being conducted at the time of writing.

VIII.4 Needs assessment and entry points for development approaches

The expressed priorities of sedentary and mobile communities represent deficits in almost all aspects of livelihoods. The communities fight for their existence, which is under threat not only from lack of access to land resources. The most fundamental needs, access to food and water are often not satisfied and human and animal healthcare services can not answer the most essential requirements. The amount and complexity of serious issues for mobile as well as sedentary communities is a real challenge to development efforts. Efforts in one sector can lead to increasing problems in another. So if for example a well is built for nomads, people would settle around it shortly after, because having access to drinking water is rare also for sedentary communities. Then access to the well for nomads would be hindered again (Fratkin 1997). Or if technical aid is given to sedentary communities to increase their harvest and improve food security, new fields would be created and mobile communities would be even more restricted

in their access to pastures and their own food security would decrease. Thus, the crucial issue is about how to intervene. As described above, a new regulatory framework that is enforced on the ground, created in a participatory process is the first priority to take into account to address the most urgent needs of mobile communities. A legal and binding regulation could contribute to improve the recurring food crisis situation, as the access to pastures and therefore the available food for animals would be predictable. Consequently, the area could be stabilised and the numerous conflicts between communities eased. This would also help sedentary communities, as their rights to agricultural areas would be clearly defined as well as the procedure in case of damage by mobile livestock. It must be understood that the benefits of such a regulation would strongly depend on the political willingness to implement the new rules in place and in the acceptance of the regulations by the local communities, which again depends on their involvement in the creation process. Once implemented, technical assistance (i.e. for building wells) could be facilitated as access rights would be defined in a legally binding way. However, local customary authorities are involved in land deals and can not be considered as honest brokers.

A second priority is healthcare for people and animals in mobile as well as in sedentary communities. The health services in the area are barely operative and health centres are scarce. For animals, the situation is even worse, apart from the compulsory vaccination services. People depend strongly on the well being of their animals for food and income, but they also have to be able and healthy themselves to tend to them. A systemic approach would be necessary, implying a better training of health personnel, contracts for a longer-term engagement and more effective communal supervision committees. Mobile health and veterinary services for mobile pastoralists as well as small villages would greatly increase access of remote and mobile communities.

As a third entry point for effective interventions, we recommend to concentrate on schooling as in the long run, better education will enable the communities to

negotiate more effectively for themselves also on a national level and create opportunities to take ownership and responsibility for their development.

When a new regulation for pastoral and agricultural zones is in place, we hope that the work load on pastoralist children would decrease as they now often have to guard the animals to keep them from entering fields, which are scattered in the middle of pastures.

Although some attempts have been made in the past for mobile schools, none is operational now to our knowledge. The conditions for teachers were difficult, as they had to cope with being on the move, and so far only “nomad” schools in sedentary (sedentarising) or semi-nomadic villages have been lasting. The first step would be to improve working conditions for teachers and to clearly define the duties of the communities. Then a close follow-up and monitoring as well as pragmatic problem solving are needed to establish the schools durably in mobile communities.

All these issues can not be solved within the short period of a usual project cycle. They have to be addressed together with the population, the authorities and external NGOs or donor organisations in a long-term commitment. A platform of dialogue and exchange could facilitate the activities in the area. The approach of stakeholder meetings as practiced by the Swiss TPH, the CSSI, local organisations as the *Association des Jeunes Nomades* but also the *Ministère de l’Elevage et des Ressources Animales* in cooperation with the European Union and the French and Swiss Development Agencies are a first step to develop a culture of dialogue. This process has to be institutionalised and established for a longer period from the first drafting of ideas until new regulations are in place and beyond.

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VIII. Conclusions

- I. The density of people and livestock in the southeastern shore area of Lake Chad is very high, increasing the risk of resource conflicts and humanitarian crisis. Ongoing participatory processes on health development should be extended to the negotiation of new regulatory frameworks for pastoralism and agriculture at national level.
- II. Integrated demographic surveillance of mobile pastoralists and their livestock is feasible, cost-effective, well accepted by the target population and leads to consistent results. An up-scaling to a mobile mHDSS is recommended and the adhesion with the INDEPTH network is foreseen. This could be combined with locally adapted interventions and real-time human and animal disease surveillance as well as environmental management. Many other perceived needs of the communities could be addressed in such a way, like education or legal advice in conflict situations.
- III. Improvements of the health status of mobile pastoralists can not be achieved through single-sector interventions. The complexity and interconnectivity of all livelihood aspects should be taken into account.
- IV. There is a high prevalence of infections with *F. gigantica* in livestock, especially cattle, herded close to the lake shores. Husbandry practices of different ethnic groups determine the risk of infection and specific measures should be taken
- V. Mobile communities do rear chicken despite their mobility. Mobile as well as sedentary communities are affected by high chicken mortalities that annihilate the whole stock. Newcastle disease is suspected, but not confirmed.

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X. Annex

Typical interview situations:



Mapping of transhumance routes



Calotropis procera (Sodom apple), a plant toxic to animals, which spreads on pastures



Swarming birds which often feed on agricultural fields



Liver incision in the slaughterslab of Grédaya and Peul women taking milk to the local market.



Different styles of housing of mobile pastoralists: 1: Gorane; 2, 3, 5.:different subgroups of Peul; 4: Arab, 6 newlywed Arab



Transhumance: Peul herds crossing Chari River to Cameroon and Transhumance with donkeys, camels and cattle



Water: Queue in front of pump, girl on cattle operating traditional well, traditional well from above and side



Study participants:





Typical situations with the field team for sleeping, cooking, preparing tea and eating



