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Journal of International Development

Provided in Cooperation with:
John Wiley & Sons

Suggested Citation: Parlasca, Martin C. (2021) : A vital technology: Review of the literature on mobile phone use among pastoralists, Journal of International Development, ISSN 1099-1328, Wiley, Hoboken, NJ, Vol. 33, Iss. 4, pp. 780-799, https://doi.org/10.1002/jid.3540

Received: 7 April 2020 | Revised: 4 January 2021 | Accepted: 4 March 2021

DOI: 10.1002/jid.3540

REVIEW ARTICLE

WILEY

A vital technology: Review of the literature on mobile phone use among pastoralists

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Funding information
German Research Foundation (DFG), Grant/Award Number: RTG1666

Abstract

Mobile phones fit well into the lives of pastoralists in low-income countries. The technology is firmly integrated into most pastoralist communities, affecting and transforming several core activities. Most studies concerned with this relationship, however, have narrow regional and thematic foci. The complementarity or discrepancy between relevant research is unknown, and a critical assessment of the current state of research is lacking. This study identifies, summarizes, and analyzes relevant studies, showing that the literature attests generally positive influences of mobile phones although some negative effects also occur. Effects on pastoralists' income, environmental externalities, and gender roles are not yet sufficiently understood.

KEYWORDS
communication, ICT, livestock, mobile phones, pastoralism, rural development

> *It is really important to be connected. I cannot understand life without a phone. […] He who does not have a mobile phone, is not alive*. Moroccan cattle breeder (Vidal-González & Nahhass, 2018)

1 | INTRODUCTION

Mobile phones enable fast, cheap, and convenient communication with a wide variety of people. The new possibilities to provide and obtain information have far-reaching implications for livelihoods, especially in rural

Africa (Aker & Mbiti, 2010; Nakasone et al., 2014; Sekabira & Qaim, 2017). Although mobile phones have been used for some time by smallholder farmers engaged in sedentary agriculture or by people not engaged in agriculture at all, recent years have seen an exceptionally rapid diffusion of the technology also amongst pastoral communities. In the arid and semiarid lands of northern Kenya, for example, the percentage of households using a mobile phone at least once a year increased from 45% in 2009 to more than 80% in 2015 (Parlasca, Mußhoff, & Qaim, 2020). Similar rates of diffusion have been observed in other pastoral societies as well (Asaka & Smucker, 2016; Djohy et al., 2017).

The adoption of mobile phones among pastoral communities is noteworthy for several reasons. The rapid diffusion of a technology in communities often considered more conservative and reluctant to embrace foreign technologies and innovations (Djohy et al., 2017) demonstrates that mobile phones can help fulfil important information and communication needs while fitting exceptionally well to the economic and social environment in which pastoralists live. Moreover, research on this topic is intriguing, because mobile phones represent the first contact with a modern information and communication tool for most pastoral communities (Debsu et al., 2016). In their seminal study on mobile phones and economic development, Aker and Mbiti (2010, p. 208) predicted that the impact of mobile phones can be "particularly dramatic" in rural parts of Africa. Against this background, the effects of mobile phones on the lives of pastoralists—most of whom live in rural areas—can be considered high.

Because access to information and opportunities for communication are relevant to a wide range of social and economic activities, mobile phones have the potential to shape and influence numerous aspects of pastoralists' daily lives. These aspects are diverse and include amongst others herd management (Butt, 2015), nutrition (Parlasca, Mußhoff, & Qaim, 2020), security (Debsu et al., 2016), human wildlife conflict (Lewis et al., 2016), and even practice of religion (Djohy et al., 2017). Yet research on mobile phone use among pastoralists is based primarily on case studies, focuses on one particular outcome dimension, or is limited to a relatively small geographical area. To date, it is unclear how these studies relate to each other, which common or divergent themes can be found across case studies, and whether certain aspects have so far been off academic researchers' radar. This literature review aims to fill these gaps by providing a comprehensive overview of how mobile phone technology has impacted pastoral populations beyond individual case studies. In light of the growing interest in pastoralists' relationship with mobile phone technology over the past 5 to 10 years, I believe that this review is timely, relevant, and expedient for academics, development practitioners, as well as policy makers.

The remainder of this article is structured as follows. Section 2 explains why the relationship between pastoralists and mobile phones is particularly intriguing and expedient. Section 3 outlines the methodology of the review. Empirical findings are summarized in Section 4. Section 5 identifies gaps, as well as methodological shortcomings of the existing literature. Section 6 concludes.

2 | BACKGROUND: THE SYNERGY BETWEEN MOBILE PHONES AND PASTORALISTS

The mobile phone technology is disseminated in most parts of Africa. Although adoption in rural areas is often below national averages, the proportion of rural households with access to a mobile phone has risen substantially in recent years: while in 2015, approximately 30% of households living in rural parts of sub-Saharan Africa did not own a mobile phone, this proportion dropped to nearly 16% in 2018.[1]

Today, mobile phones are nearly ubiquitous in most pastoral communities. The fast adoption of mobile phones in populations that are mostly considered conservative and sceptical towards foreign technologies (Djohy et al., 2017) is remarkable and suggests that the mobile phone technology fits exceptionally well into the context of pastoralism. The unique synergy between pastoralism and mobile phones indicates that in terms of how mobile phones are used and the effects they have on livelihoods, pastoral communities differ from other populations, such as smallholders engaged in sedentary agriculture.

The high value of mobile phones for pastoralists is driven by multiple information and communication needs including information on livestock prices and volumes, forage availability, location of water supplies, current state of conflicts, onset dates of rains, flooding events, or the delivery of food aid (Rasmussen et al., 2014; Seid et al., 2016). These types of information are traditionally acquired by inquiring friends, family, or trusted seers (Balehegn et al., 2019; Rasmussen et al., 2014).

The mobile phone has several characteristics and features that comply with the situation and lifestyle of most pastoral communities. Mobility presents a key aspect in this regard. Mobility is at the core of many pastoralists' lives, and being mobile can be seen as a centrepiece of pastoralists' resilience (Cissé & Barrett, 2018), livelihood (Adriansen, 2008; Turner & Schlecht, 2019), and even identity (de Bruijn et al., 2016). In order for a technology to fit well into pastoralists' lives, mobility, therefore, represents a highly desirable trait. In opposition to landline phones, for example, the mobile phone technology—even carrying the aspect in its very name—is portable and therefore meets this need.

The relative ease of acquiring and using a mobile phone presents another vital aspect that explains the strong synergy between pastoralists and mobile phones. Using a phone is relatively intuitive and does not require high individual capabilities. Integration into public administration and literacy are particularly noteworthy capabilities. Prepaid subscriptions of mobile phones do not necessitate strong levels of integration into public administration. In most cases, users are neither required to have a bank account, a postal address, nor a steady source of income. Prepaid contracts are therefore particularly appealing to people without such integration or regular income (Gillwald, 2005).

As mobile phones allow oral communication, many pastoralists can use them with relative ease. Oral communication is still paramount for information exchange among most pastoralists (Mertz et al., 2016; Seid et al., 2016), also because low levels of literacy make other forms of communication-based on written words or numbers challenging. Several communities have developed sophisticated oral communication traditions, such as the *dagu*, which is a traditional and reputable network by Afar pastoralists in Ethiopia (Balehegn et al., 2019; Seid et al., 2016). These communication systems and traditions play an important role in receiving and providing information. Communication based on spoken words or voice messages has the potential to be embedded in these informal traditions (Nilsson & Salazar, 2017) thereby facilitating the adoption and integration in already established communication practices.

Compared with other infrastructural projects that facilitate communication such as the construction of paved roads or the establishment of an exhaustive landline phone network, the mobile phone technology requires relatively small investments by governments or private companies. In addition, most pastoral communities inhabit vast landscapes and the large plains can facilitate signal transmission (Vidal-González & Nahhass, 2018), further increasing the cost–benefit ratio of this technology compared with roads or landline phones.

3 | METHOD

The literature review presented in this study aims not only at connecting case studies to find common themes but also at identifying areas where studies reach different or even contradicting conclusions regarding the relationship between mobile phones and pastoralists. To this end, this review aims to address two main research questions. The first question asks what is known about the purposes for which pastoralists use mobile phones. The second question asks what is known about the effects of mobile phones on the lives of pastoralists. Ultimately, this review aims to identify areas of inquiry that remain underresearched.

So far, the number of studies related to this topic is too small to allow for a robust meta-analysis or meta-synthesis. This study therefore presents an exploratory literature review. The Web of Science was used as the primary search system to find relevant studies. This platform has shown to be an appropriate principal search system for literature reviews because it allows effective, efficient, and reproducible literature searches (Gusenbauer & Haddaway, 2020). Additionally, two scientific journals that are not included in the Web of Science, but specifically

publish research related to pastoralists—namely *Nomadic Peoples* and *Pastoralism*—were scanned for relevant articles. The snowball method was then applied to identify and add undiscovered relevant literature using Google Scholar and EconLit as supplementary search engines.

A study included in this review meets five criteria. First, it describes how mobile phones are used or it analyses at least one effect associated with mobile phone use. Second, the study either provides results based on respondents that are pastoralists or is conducted among a population for which pastoralism is explicitly claimed to be the main form of livelihood. Due to the general trend of increasing diversification of livelihoods among pastoralists (Baird & Hartter, 2017; Galvin, 2009; Little et al., 2001), few households rely on livestock as their sole form of livelihood. Other forms of income generation and food production including agriculture become relevant at least during some periods of the year (Berhanu et al., 2007; Little et al., 2001). This makes a clear conceptual distinction between agro-pastoralists and pastoralists difficult for some cases. Studies on agro-pastoralists are therefore also included if the authors explicitly mention that livestock production is the main component of the analysed population's livelihood.

The third criterion requires the study to have a regional focus on low- or middle-income countries. Pastoralism and the information and communications technology (ICT) sector in high-income countries can be quite different from settings in low- or middle-income countries. This makes aggregation of findings difficult.

The fourth criterion requires the study to be an article from a peer-reviewed journal. This exclusionary criterion causes some potentially relevant work to remain unregarded but is indispensable for the review: the peer-review process ensures that the effects of mobile phones described in a study are based on valid methodologies and are sufficiently identified according to peer-review standards. Because private sector companies and nongovernmental organizations working in the ICT sector can have interests to exaggerate or overstate any potentially positive effect of the mobile phone technology, this review relies solely on academic articles, which ought to be more independent of any financial or political interests.

The fifth criterion requires the study to be written in English. Overall, 34 studies have met the above-mentioned criteria and are analysed in the review at hand. The individual studies are listed and briefly summarized in Table 1. Of these 34 studies, 16 studies have mobile phones as their main focus point. Mobile phones are of mediocre relevance for seven studies, and the technology only plays a minor role in 11 studies.

To summarize the main empirical findings, I first reviewed each article and collected its findings related to mobile phone use. I then organized these findings into common topics to reveal any converging or diverging results across studies. The topics that I identified are income, herd management, health and nutrition, conflict, social structure, and others.

4 | REVIEW OF EMPIRICAL EVIDENCE

This section summarizes and analyses the main results of empirical research for each of the six categories outlined in the previous section.

4.1 | Income

Mobile phones can affect pastoralists' income through several channels. One of the channels is the acquisition of information on prices for livestock. This activity is widespread among pastoralists and frequently mentioned across several studies and contexts (Baird & Hartter, 2017; Karimuribo et al., 2016; Little et al., 2014; Mertz et al., 2016; Mtimet et al., 2018; Roba et al., 2018; Vidal-González & Nahhass, 2018). The pastoral meat supply chain is characterized by high price variability. Prices are usually not known until the market day and delayed payments occur frequently (Roba et al., 2017; Roba et al., 2018). This makes negotiations between traders and pastoralists on livestock purchases challenging. The mobile phone allows gathering reliable information on livestock prices quickly by calling contact

TABLE 1 List of peer-reviewed publications concerned with mobile phone use among pastoralists

Publication	Country	Region (if applicable)	Data and research methods	Targeted group (if applicable)	Focus on mobile phones
Abakar et al. (2018)	Chad	Southern Chad	Qualitative - Key informant in-depth interviews (*n* = 12) - FGD (*n* = 35)	Caregivers, traditional chiefs, local and religious leaders from mobile pastoralist communities, and health officials and staff.	Minor
Abakar et al. (2016)	African countries		Review of Studies		Medium
Asaka and Smucker (2016)	Kenya	Samburu	Qualitative - Research workshop (*n* = 21) - Key informant interviews (*n* = 13)	Participants of workshops were community members, key interviews were held with community, government, and civil society	Main
Baird and Hartter (2017)	Tanzania	Simanjiro	Mixed - Semistructured group interviews (*n* = 14) - Structured survey (*n* = 104)	Agro-pastoralist Maasai. Semistructured group interviews were held with community members and leaders. Structured survey with household heads who own and use mobile phones	Medium
Balehegn et al. (2019)	Ethiopia	Ab'alá district (Afar Region)	Qualitative - FGD (*N* = 6) - Survey interviews (*N* = 85) - Feedback workshop (*N* = 1)	Afar pastoralists; FGDs were held with community leaders, elderly men, elderly women, clan leaders, herders and local pastoral, and agricultural office personnel; survey interviews were held with household members; feedback workshop was conducted with traditional weather forecasting seers, clan leaders, elderly women and young herders.	Minor
Bauer and Mburu (2017)	Kenya	Marsabit	Quantitative - Panel of individual and household survey data 2009–2013, (*n* = 3589)	Households in northern Kenya's Marsabit district	Minor

(Continues)

TABLE 1 (Continued)

Publication	Country	Region (if applicable)	Data and research methods	Targeted group (if applicable)	Focus on mobile phones
Butt (2015)	Kenya	Maasai Mara National Reserve	Qualitative - Semistructured interviews (n = 30)	Semistructured interviews were held with herders aged 18–45	Main
Bruijn et al. (2016)	Cameroon, Chad, Mali		Qualitative - 3 case studies - Biographical narratives	nomadic and seminomadic pastoralists who have lived through conflict and violence in Cameroon, Chad, and Mali	Main
Debsu et al. (2016)	Ethiopia	Dikale & Kanicharo	Mixed - Questionnaire (n = 206) - Unstructured interviews ($n \approx 20$)	Borana pastoralists and traders. Key informant interviews were held with government and non-government officials and local leaders.	Main
Djohy et al. (2017)	Benin	Alibori Province	Qualitative - Semistructured interviews (n = 380)	Fulani male and Muslim pastoralist household heads	Main
Fraser (2018)	Mongolia	Khövsgöl aimag	Qualitative		Minor
Hahn (2020)	Mongolia		Ethnographic fieldwork		Main
Jean-Richard et al. (2014)	Chad	Southeast of Lake Chad	Mixed - Longitudinal study conducting biweekly mobile telephone interviews (490 interviews with 83 households)	Mobile pastoralists from three ethnic groups (Foulbé, Gorane, seminomadic Arab people)	Main
Karimuribo et al. (2016)	Tanzania	Morogoro	Quantitative - Survey (n = 138)	Voluntary members of a beef and milk value chain innovation platforms	Main
Kaufmann et al. (2016)	African countries		Review of studies		Minor
Lewis et al. (2016)	Tanzania	Simanjiro District	Mixed - Group interviews (n = 12) - Survey with household heads (n = 144)	Maasai, agro-pastoralist communities	Main
Little et al. (2014)	Kenya, Ethiopia	northern Kenya, Southern Ethiopia	Quantitative - Longitudinal data (quarterly during 2000–2002, n = 303) - Panel data (n = 618)	Members of pastoralist communities, livestock traders	Medium

(Continues)

TABLE 1 (Continued)

Publication	Country	Region (if applicable)	Data and research methods	Targeted group (if applicable)	Focus on mobile phones
Matsaert et al. (2011)	Kenya	Marsabit	Innovation System Approach		Minor
Mertz et al. (2016)	Sahel countries (Burkina Faso, Mali, Niger)		Mixed - Review of studies - Short questionnaire with key informants (n = 16)	Pastoralists and farmers in the Sahel. Interviews were held with local government and private stakeholders involved in dissemination of climate, weather, and resource information	Medium
Mtimet et al. (2018)	Somaliland	Hargeisa	Qualitative - Interviews - FGD	Members and trainers of the Somaliland Meat and Development Association (SOMDA)	Minor
Mwantimwa (2019)	Tanzania	Coast Region & Arusha Region	Mixed - Survey (n = 320) - Semistructured interviews (n = 30) - FGD (n = 48)	Members of agro-pastoralist communities	Main
Nilsson and Salazar (2017)	Tanzania	Ngorongoro Conservation Area	Ethnographic fieldwork	Seminomadic Maasai	Main
Opiyo et al. (2015)	Kenya	Turkana	Mixed - Socioeconomic interviews (n = 302) - FGDs, and informal interviews (n = 10)	Households in Turkana County	Minor
Parlasca, Hermann, and Mußhoff (2020)	Kenya	Turkana	Quantitative - Experiment and survey (n = 402)	Households in Turkana County	Main
Parlasca, Mußhoff, and Qaim (2020)	Kenya	Marsabit	Quantitative - Panel of household data 2009–2015 (n = 5,506)	Households in northern Kenya's Marsabit district	Main
Rasmussen et al. (2015)	Burkina Faso	Seno province	Mixed - Survey (n = 61) - Semistructured interviews (n = 43)	Survey and semistructured interviews with Fulbe pastoralist households, Semi structured interviews with boundary institutions and organizations that facilitate the interaction between producers and end-users of climate and weather information	Main

(Continues)

TABLE 1 (Continued)

Publication	Country	Region (if applicable)	Data and research methods	Targeted group (if applicable)	Focus on mobile phones
Rasmussen et al. (2014)	Burkina Faso	Seno province	Mixed - Survey (*n* = 61) - Semistructured interviews (*n* = 43) - FGD (*n* = 8)	Fulbe households who are predominantly pastoralists	Medium
Roba et al. (2018)	Kenya	Marsabit	Qualitative/mixed - FGD (*n* = 18) - Interviews (*n* = 26) - Semistructured interviews (*n* = 40) - Narrative interviews (*n* = 4) - Expert interviews (*n* = 11)	FGD with traders and livestock producers; interviews with long distance traders, itinerant traders, and local market traders; semistructured interviews with livestock producers and traders; narrative interviews with traders, expert interviews with long-distance traders	Medium
Schelling et al. (2016)	Sahel countries		Review of studies	Pastoralist communities and livestock	Minor
Schilling et al. (2012)	Kenya	Turkana & West Pokot	Qualitative - Social survey and FGDs (*n* = 376)	Chiefs, elders, women, herders, youth, and raiders of Turkana and Pokot communities	Minor
Seid et al. (2016)	African countries		Review of studies		Medium
Summers et al. (2020)	Tanzania	Simanjiro & Longido	Qualitative - Semistructured group interviews (*n* = 72) - Individual stakeholder interviews (*n* = 4)	Semistructured group interviews and individual stakeholder interviews were held with selected women	Main
Vidal-González and Nahhass (2018)	Morocco	City of Bouarfa (Eastern Region)	Qualitative - In-depth semistructured interviews (*n* = 19) - Participant observation and market visits	Interviews were conducted primarily with men involved in livestock raising such as local authorities, agricultural technicians, and sheep-owners	Main
Yu and Farrell (2016)	China	Yanchi, Ejin Horo Bannerm East Ujimqin Banner, Xilinhot City	Mixed First round of data collection - Structured Interviews (*n* = 216) - FGDs, and semistructured interviews;	Agro-pastoralist or nomadic pastoralist communities. Participants of structured interviews were households, FGDs were held with elderly, semistructured interviews were held	Minor

(Continues)

TABLE 1 (Continued)

Publication	Country	Region (if applicable)	Data and research methods	Targeted group (if applicable)	Focus on mobile phones
			- participatory observations and in-depth semistructured interviews - Second round of data collection - Semistructured interviews (n = 105)	with administrative officials, representatives from non-governmental organizations, and village leaders	

Note: FGD = focus group discussion. Last update: 04.01.2021.

persons at livestock markets or other knowledgeable sources. The usefulness of a mobile phone in this regard, however, depends on the user's position in the supply chain (Debsu et al., 2016). The mobile phone is widely considered to have brought a major positive breakthrough for traders (Debsu et al., 2016; Little et al., 2014; Roba et al., 2018), especially for long-distance traders that transport livestock to markets that are far away (Roba et al., 2018). How much herders use and benefit from the acquisition of information on livestock prices via mobile phones is less clear. In principle, herders can use the mobile phone to check prices in different markets, reducing information asymmetry and unreasonable prices (Vidal-González & Nahhass, 2018). However, because most herders are less market-oriented than traders (Djohy et al., 2017), herders may use and benefit from mobile phones less than traders (Debsu et al., 2016). The information on livestock prices at different markets that traders acquire through their mobile phone might increase the price traders are willing to offer herders. Herders could therefore also indirectly benefit from traders' mobile phone use. So far, however, it is unclear whether such trickle-down effects actually occur.

The reception of remittances from family, friends, or business partners via mobile money services presents another channel through which mobile phones can enhance income. This channel is vital especially for people residing in remote rural areas (Kikulwe et al., 2014). A few studies show that pastoralists do indeed use mobile phones to send and receive money (Baird & Hartter, 2017; Matsaert et al., 2011; Mwantimwa, 2019; Nilsson & Salazar, 2017; Opiyo et al., 2015; Summers et al., 2020). The mobile phone thereby helps pastoralists save money and improves their ability to manage risks such as droughts, floods, or severe illness (Matsaert et al., 2011; Opiyo et al., 2015). However, these studies exclusively focus on Kenya or Tanzania, two countries with well-developed and widely used mobile money platforms. Research on pastoralists from other regional contexts has not mentioned such activities. Beyond remittances, research in Kenya and Morocco shows that pastoralists use the phone to find and manage alternative income generating activities (Baird & Hartter, 2017; Vidal-González & Nahhass, 2018).

4.2 | Herd management

The emergence of mobile phones strongly influences herd management of pastoralists as well. Herders inquire and provide information on several important aspects including information on forage and water resources, on the location of rangers who might disrupt herding practices, on weather conditions, or on situations that require veterinary assistance (Baird & Hartter, 2017; Butt, 2015; Debsu et al., 2016; Djohy et al., 2017; Nilsson & Salazar, 2017; Rasmussen et al., 2014; Vidal-González & Nahhass, 2018). How much pastoralists utilize the mobile phone is context dependent. Identifying the location of vital resources such as adequate grazing areas is most challenging during dry seasons, prompting mobile phone communication on this topic to increase during these times of the year

(Butt, 2015). Similarly, information on onset dates of rain is particularly important during the first weeks of rain (Rasmussen et al., 2014). Information requirements can also vary over the course of a day. Information on the location of rangers, for example, is less important during night because rangers are usually not present during that time (Butt, 2015).

Reception and provision of information on resources and water availability are important aspects of pastoralists' herd management as well. For Sahelian pastoralists in Burkina Faso, the mobile phone represents by far the most used and the most preferred method for these activities because it allows the transmission of timely and site-specific information (Rasmussen et al., 2015). Additionally, climate change has rendered other channels to obtain such information—for example, traditional forecasting methods—less reliable (Rasmussen et al., 2014; Rasmussen et al., 2015). Some scholars suggest that mobile phones could be used to build an indigenous knowledge database, combining data from modern stations with the valuable indigenous knowledge that pastoralists have acquired over time (Balehegn et al., 2019). This combination has the potential to bridge the lack of trust among pastoral communities towards external knowledge producers (Rasmussen et al., 2015). However, because pastoralists require highly time-specific and recent information on weather conditions, such databases need to have a substantial resolution with very frequent updates. To the best of our knowledge, no platform of such kind is therefore currently under operation.

A few challenges to the exchange of information on key resources do, however, exist and limit the usefulness of mobile phone communication for grazing strategies. A key issue is the complexity of some of the information needed to plan grazing routes. Forage conditions for example may encompass a range of ecological and anthropogenic indicators, which can be too complex to be shared via mobile phone (Asaka & Smucker, 2016). Additionally, some resources, such as water points or good grazing land, can be so valuable that deliberately false information is spread about whether and where these resources are available (Asaka & Smucker, 2016; Butt, 2015; Nilsson & Salazar, 2017). Although Butt (2015) found that purposeful provision of false information is restricted to water and forage resources that are highly contested, Asaka and Smucker (2016), Baird and Hartter (2017), and Nilsson and Salazar (2017) argued that the issue of purposeful provision of false information is more extensive. Implications of mobile phones on social trust and personal relationships are discussed in more detail in later sections.

All in all, communication via mobile phone is an important channel to exchange information related to grazing strategies. For Sahelian pastoralists, mobile phones are even more important than scouts (Rasmussen et al., 2015), whereas research on East African pastoralists shows that false information and mistrust severely reduce the value of mobile phone communication in this aspect (Aker & Mbiti, 2010; Butt, 2015). This is one of the reasons why mobile phones have not fully replaced the traditional way of travelling in person (Debsu et al., 2016).

Mobile phones have also shown to help herd management related to unplanned or distressing events such as illnesses or injuries within the herd, cows giving birth, or livestock gone missing (Baird & Hartter, 2017; Debsu et al., 2016; Djohy et al., 2017; Fraser, 2018; Karimuribo et al., 2016; Lewis et al., 2016; Nilsson & Salazar, 2017; Seid et al., 2016; Summers et al., 2020). In several contexts, pastoralists use the mobile phone to seek advice from veterinaries or to organize the purchase of veterinary drugs (Baird & Hartter, 2017; Fraser, 2018; Karimuribo et al., 2016; Lewis et al., 2016). The Fulani pastoralists in Benin even take pictures or record video clips of their livestock with their mobile phone to present them to trusted veterinarians (Djohy et al., 2017). The mobile phone furthermore improves communication between key actors of community-based health approaches, such as veterinarians, local representatives, traditional healers, and livestock owners. Thereby, mobile phones are crucial tools for successful community-based health approaches, such as community animal health worker systems, which have shown to help detect emerging epidemics in Uganda or Southern Sudan (Seid et al., 2016).

4.3 | Health and nutrition

Mobile phones are also used to improve human health care among pastoral communities. The technology helps improve health both structurally and situationally: From a structural perspective, mobile phones have the potential

to enhance health care among pastoral communities by enabling improved demographic surveillance (Brinkel et al., 2014). For achieving this, mobile pastoral camps could use the phone to provide local health officers with continuous information on population structures, pregnancy outcomes, and migration patterns. With this information, health services may be able to include pastoralists in fixed or outreach services, such as vaccinations. Research among three different pastoral tribes in Chad shows that such approaches can deliver affordable, usable, and valid information, which improves planning and provision of human and animal health services (Jean-Richard et al., 2014). However, Abakar et al. (2016) argued that for the development of successful and sustainable mobile phone-based health and surveillance systems, it is paramount that such systems are well adapted to the respective culture and cost-efficient. In an example related to immunization programmes in Chad, Abakar et al. (2018) emphasized that the lack of communication between remote pastoralists and the local health system is a core barrier to the success of such programmes. Abakar et al. (2018) then proposed that mobile phones could help alleviate this communication barrier. Whether such improvements actually occur, however, is not further elaborated.

Taking a more situational perspective, mobile phones also seem to promote human health. Pastoralists can use a phone to contact medical assistance quickly during urgent types of health crises such as complications with pregnancy (Baird & Hartter, 2017) or snake bites (Lewis et al., 2016). Because late medical attendance is a main cause of maternal and neonatal mortality among pastoral communities (Schelling et al., 2010), the mobile phone presents an invaluable tool during such emergencies. On the downside, mobile phones may also have negative effects on health. If accidents happen in areas with weak network coverage, treatment is delayed when women do not seek help from nearer, accessible male chaperones, but rather wait until the husband might be reached by phone (Schelling et al., 2016). All of the assessments on health that we are aware of are based on qualitative data.[2] I am not aware of studies based on quantitative analyses that could hint towards the magnitude of the effect of mobile phone availability or mobile phone use by pastoralists on their health, be it positive or negative.

Furthermore, mobile phones can improve nutrition among pastoral communities. Parlasca, Mußhoff, and Qaim (2020) showed that mobile phone use substantially increases dietary diversity amongst pastoralists in northern Kenya. This positive effect is also achieved because mobile phones allow better access to markets for food purchases. Positive effects of mobile phones on nutrition are also identified by Bauer and Mburu (2017), who use anthropometric measurements to show that having a mobile phone in the household improves children's nutritional status. Bauer and Mburu (2017) suggested that this positive effect may be caused by households using the mobile phone to inform themselves on times and places of food aid deliveries.

4.4 | Conflict

Pastoral communities are oftentimes exposed to different types of conflict including human–wildlife conflicts, conflicts between livestock herders and authorities of protected areas, conflicts between livestock herders and sedentary farmers, and conflicts between different tribes. Because the mobile phone allows fast and cheap exchanges of information, pastoralists use the technology to prevent conflicts before they occur, but they also use them strategically in ongoing conflicts. For example, mobile phones have shown to reduce conflicts between pastoralists and wildlife in East Africa, because herders use the phone to share information on sightings of dangerous species, their footprints or their dung, with other herders (Butt, 2015; Lewis et al., 2016). The technology thereby helps decrease the number and severity of human–wildlife conflicts (Lewis et al., 2016). The role of mobile phones in conflicts between people are more complex, as the phone leads to a reduction of conflicts in some cases and an increase of conflicts in other cases. Mertz et al. (2016) argued that in the Sahel, mobile phones usually help resolve conflicts between pastoralists and sedentary farmers, because pastoralists obtain information on retracting water from lakes, which allows them to avoid areas where farmers start growing their crops. However, the mobile phone also aggravates conflicts, especially during times when little water and forage resources are available to pastoralists. Due to mobile phone communication, more pastoralists are aware of the location of precious resources and direct their

livestock to these places. The fierce competition for the resources then provokes conflicts among pastoralists (Mertz et al., 2016).

Mobile phones have also been integrated into the "cat-and-mouse game" (Butt, 2015, p. 7) between pastoralists and authorities of protected areas. Most protected areas have vast ranges with decent forage conditions, also because livestock grazing is mostly prohibited in these areas. Some herders, therefore, try to enter and graze their livestock illegally.[3] Getting caught doing so usually implies severe punishment for the herder. To avoid being caught, pastoralists who live close to protected areas commonly use the mobile phone sharing information on the location and activities of park authorities with their peers. This behaviour, which facilitates illegal grazing activities in protected areas, has been found for Maasai pastoralists in East Africa as well as for Fulani pastoralists in West Africa (Butt, 2015; Djohy et al., 2017; Nilsson & Salazar, 2017). Whether and how park authorities use mobile phones to counteract this development is not discussed in the existing literature.

The effects of mobile phones on conflicts between tribes are also ambiguous. While mobile phones help targeted communities and administrative authorities notice and prepare for imminent raids, mobile phones also help raiding parties organize and arrange their attack. Schilling et al. (2012) thus argued that the mobile phone has led to smaller but more frequent raids in northern Kenya. Debsu et al. (2016) argued that pastoralists use the mobile phone to acquire information on the security situation of a region that might be visited with the herd. This suggests that mobile phones can help pastoralists avoid security risks. In contrast to that, mobile phones also bear the potential to facilitate or put forth new types of security risks: Baird and Hartter (2017) mentioned situations in which pastoralists were ambushed by robbers when they carried larger amounts of money. Here, the robbers are thought to have received information from market snoops about persons that are carrying money via mobile phone communication. These examples show that the increase in information that is made possible through mobile phones does not unilaterally increase or decrease conflicts but rather leads to a more complex transformation of conflict types and severity.

4.5 | Social change

Information and knowledge are key assets for members of pastoral communities. Having access to information resembles power (Nilsson & Salazar, 2017). In most pastoral communities, access to information and knowledge traditionally depends on a person's gender, age, and position within the society. The emergence of the mobile phone has stirred up this traditional information distribution because the mobile phone facilitates information access and sharing also for previously deprived social groups (Djohy et al., 2017). These changes in access to information and power relations affect the societies of pastoral communities along several dimensions.

First, mobile phones affect gender roles and female empowerment in pastoral communities. The effects of mobile phones on female empowerment in sub-Saharan Africa in general are ambiguous. Whereas some research shows that mobile phones increase females' access to employment, income, education, and health services (Hilbert, 2011), others do not find much evidence of such positive transformative change and even show cases in which men use mobile phones to control women, which further constraints women's empowerment (Porter et al., 2020).

A few studies touch upon this complex relationship in the context of pastoral communities. Female Maasai in Northern Tanzania, for example, stated that the mobile phone helps them organize their home-making tasks while still being able to stay in contact with their hired herders (Nilsson & Salazar, 2017). Further research among Maasai in Tanzania suggests that the mobile phone assists young women in opposing the traditional polygyny by enabling access to information on their rights to attend school and preventing or delaying arranged marriage (Baird & Hartter, 2017). Mobile phones are argued to have only limited impact on the lives of women among Fulani pastoralists in Benin or among pastoralists in Morocco, because mobile phone users in these contexts are mostly male (Djohy et al., 2017; Vidal-González & Nahhass, 2018) and because traditional gender roles cause women to pursue domestic activities in which the mobile phone is not as useful as in men dominated activities such as herding or

selling livestock (Vidal-González & Nahhass, 2018). Summers et al. (2020) presented the most detailed and in-depth analysis related to the role of mobile phones in women's empowerment among pastoralists. In their study, which also focusses on Maasai in Tanzania, Summers et al. (2020) showed the complexity and diversity of the effects of mobile phones on women's empowerment. Although some men permit or even support their wives' mobile phone use, men represent a key barrier for women's access to mobile phones. Summers et al. (2020) emphasized the heterogeneity of women's identities and present evidence that phones can be used to both empower and disempower women. In some aspects, mobile phones may even help empower the same woman in some ways and disempower her in others. However, further and more in-depth investigation of the effects of mobile phones on gender aspects is much needed. This is particularly true for pastoral tribes other than the Maasai, because most research on gender aspects has been focused on this context.

Second, the mobile phone creates new possibilities—not only for younger generations—affecting the tradition and identity of pastoral communities. Several cases show how the mobile phone helps preserve and develop pastoral traditions and identities. For example, the mobile phone facilitates finding alternative livelihood sources complementing traditional pastoral activities off which alone a family might not be able to live. Vidal-González and Nahhass (2018, p. 1088) therefore argued that the mobile phone "ensures the survival of traditional economic activities among livestock-raising communities." Mobile phones also present an invaluable tool for displaced pastoralists who fled from war, because such refugees can use the phone to connect with people that are far away. de Bruijn et al. (2016) documented that for the Mbororo, who are a group of pastoralists who fled the Central African Republic and now live in Cameroon, communication with distant people resembles their traditional form of mobility and therefore has become a vital aspect of their lives. Refugees also store cultural items and pictures on their phone, which ensures the preservation of their pastoral identity (de Bruijn et al., 2016). Similarly, Fulani pastoralists in Benin fill their phones with Fulfulde and Arab music "to remind and inculcate the basic norms of Fulani everyday life" (Djohy et al., 2017, p. 126).

The mobile phone is well integrated into many pastoral societies. However, rather than transforming traditions, the mobile phone is thought to be embedded into the existing culture (Nilsson & Salazar, 2017). The mobile phone, for example, is used widely by Maasai and Fulani pastoralists for the essential tradition of frequent information exchange (Djohy et al., 2017; Nilsson & Salazar, 2017). It is worth mentioning that Maasai do not view such information exchange via phone as inferior to communication in person (Nilsson & Salazar, 2017). However, as mentioned in the context of herd management, this preference is context dependent.

The literature also provides examples in which the mobile phone is proclaimed to have negative effects on pastoral tradition and identity. Concerns and critique on the technology are frequently raised especially among elder generations of pastoral communities. One concern is based on the fear that people cannot handle the large amount of information and filter out what is actually relevant for them. Furthermore, because access to information and knowledge is no longer restricted to elders, some people fear that the traditional hierarchy and stability of a society is being undermined (Nilsson & Salazar, 2017). Older herders in China also worry that younger generations do not have the same passion and commitment to their livestock, because they rather use the mobile phone to listen to music, chat with friends, or play video games (Yu & Farrell, 2016). That said, the existing literature generally anticipates a positive development of the mobile phone with regard to the tradition of pastoralism. Although some parts of the tradition are likely to change, diminish, or might even cease to exist due to the mobile phone, the technology offers countless new perspectives and opportunities for the members of pastoral communities.

The third aspect of social effects of mobile phone relates to the practice of religion. Two studies have so far briefly tapped into this relationship. Christian members of pastoral communities, for example, sometimes use their phone to store church music or sermons (Baird & Hartter, 2017). These media files can then be played on various occasions and be shared with other pastoralists. In Islamic communities, mobile herders additionally use the mobile phone as an alarm to signal prayer times. The phone thereby functions as the "muezzin who reminds [of] religious obligations in the bush" (Djohy et al., 2017, p. 126). Through these mechanisms, the mobile phone could strengthen existing religious affiliations, although the evidence on this relationship is so far only anecdotal.

The fourth aspect relates to social trust within pastoral communities. Parlasca, Hermann, and Mußhoff (2020) analysed how mobile phone use affects trust between people in pastoral communities of northern Kenya. Although the authors do not find any statistically significant effects of trust between people who live in the same village or between people who live in different villages, mobile phones cause substantial increases in pastoralists' trust towards city dwellers from the county capital. Parlasca, Hermann, and Mußhoff (2020) do not show precise mechanisms for this increase in trust but suggest it may be driven by the ability of mobile phones to increase communication and thus social trust especially to people who live far away.

4.6 | Other

Pastoralists also use the phone to provide authorities or project planners with data to support evaluation and improvements of programmes or services. In this case, the mobile phone does not help the pastoral who provides the information instantly but rather helps create or improve common goods that benefit the broader pastoral community in the future. Demographic surveillance is one such service that can be improved with the help of mobile phones as mentioned earlier (Jean-Richard et al., 2014). Furthermore, mobile phones can facilitate co-enquiry methods that integrate pastoralists into the collection of data, for example, to evaluate animal performance and breeding values of livestock (Kaufmann et al., 2016). Close collaboration with pastoralists into data collection via mobile phones is likely to generate more reliable, more accurate data and—as it allows the inclusion of very remote respondents—also, more representative data compared with collection strategies with less inclusive methods.[4] But also beyond the stage of data collection, Hahn (2020) argued that mobile phones could be appropriate tools for researchers to report back to nomadic communities and share results of research studies with all who were involved in the collection and analysis of the data.

Mobile phones might even influence the education of pastoralists. Because the mobile phone is perceived as an extremely useful tool, Djohy et al. (2017) mentioned that some pastoralists enrol for literacy classes to increase their benefits from this technology. However, Djohy et al. (2017) did not provide a source or evidence that suggests that mobile phones have an effect on education among pastoral communities. This claim should therefore be viewed with some caution.

5 | RESEARCH GAPS AND METHODOLOGICAL SHORTCOMINGS

Based on the empirical findings presented in the previous section, I identified several relevant research gaps regarding the relationship between pastoralists and mobile phones. The first research gap relates to the implications of mobile phone use on household income and expenditure. Income is a key welfare dimension and—as pastoral communities increasingly integrate into the cash economy—also becomes more and more relevant in this particular context. Several studies report that pastoralists use mobile phones at least for some of their income-generating activities, such as herding and livestock trading (see Sections 4.1 and 4.2). Positive effects on income are therefore plausible, also because such effects can be seen in other, less rural, settings in low-income countries (Aker & Mbiti, 2010; Muto & Yamano, 2009; Sekabira & Qaim, 2017). Nevertheless, precise implications of mobile phone use for pastoralists' household income and expenditure remain largely uncertain and therefore represents an important research gap. For example, it is unclear if and by how much households' incomes rise *precisely because* they use a mobile phone. These effects will depend on the types of income-generating activities performed by the household, because it is repeatedly mentioned that traders, for example, are likely to benefit more from mobile phones than herders (Debsu et al., 2016; Roba et al., 2018). How much financial effects of mobile phone use actually differ is, however, unknown. The focus on traders and herders in the existing literature also leaves mobile phones' effects on other types of income generating activities such as crop production, petty trading, casual labour, or employment

largely untouched. Given the increasing income diversification among most pastoral communities, this represents an important task for future research.

Substitution effects in household spending due to mobile phone use are also underresearched. Mobile phones may increase incomes, as mentioned above, and thereby increase the money available for consumption or savings. However, the costs related to the acquisition and use of a mobile phone are substantial for many pastoral households (Debsu et al., 2016; Summers et al., 2020). These costs are higher for remote pastoralists because mobile phone batteries have to be recharged with portable diesel generators or solar panels rather than via grid electricity (Debsu et al., 2016). Therefore, it is possible that these costs crowd out other areas of household spending, such as for food or education. In-depth analyses of mobile phones' effects on different areas of household expenditure are therefore encouraged.

The second research gap relates to ecological implications of pastoralists' mobile phone use. In particular, land-use change and overgrazing are two aspects that are both highly relevant but have so far been mostly neglected by the existing literature on the implications of mobile phone use. As mentioned previously, the mobile phone is well integrated into pastoralists' herd management. Many pastoralists use the mobile phone to gather information on grazing areas and use this information for their migration patterns and grazing strategies. As a result, the mobile phone is most likely to affect land use and the incidence or severity of overgrazing. Baird and Hartter's (2017) study is, however, the only study that taps into this issue. As this relationship was not at the centre of Baird and Hartter (2017), the authors only offer the conclusion that mobile phones potentially decrease or increase land conversion and degradation. Further research on the implications of mobile phone use on broader ecological dimensions is therefore warranted.

The third research gap relates to the mobile phones' influence on female empowerment. This research gap becomes apparent in the previous section and is mentioned by other researchers as well (Debsu et al., 2016). Overall, the literature proposes that mobile phones help rural populations in low-income settings more than they do harm. This narrative has recently been put into question. Benefits of mobile phone use are not equally distributed in the society, and women in low-income countries often miss out. In some cases, mobile phones can even weaken female empowerment (Porter et al., 2020; Summers et al., 2020; Wyche & Olson, 2018). While Summers et al. (2020) have recently provided a detailed assessment of female mobile phone use within the context of Maasai pastoralists in Tanzania, more research also for other cultural environments is therefore urgently needed.

Next to these three research gaps, this literature review also reveals three main methodological shortcomings. The most important shortcoming is the scarcity of studies with data that are representative for a larger population. As shown in Table 1, qualitative and mixed methods dominate the existing literature. The samples of most studies are therefore not random but are rather designed to cover several key stakeholders. These analyses are useful and justified but make correct conclusions on underlying populations, for example, regarding penetration rates or the actual degree of dissemination of certain mobile phone practices challenging. This applies just as much to studies with quantitative analyses based on selective or convenient sample designs. For results that are inclusive to very remote pastoralists and to people that live on the margins of society, it is indispensable to have representative samples in which each household (or even individual) has an equal chance of being included. Although some studies explicitly strive for representativeness at least for a certain subpopulation (e.g. Bauer & Mburu, 2017; Mwantimwa, 2019; Parlasca, Mußhoff, & Qaim, 2020; Schilling et al., 2012), future research should put a higher emphasis on this matter to improve the external validity of quantitative results.

In general, there seems to be a lack of quantitative studies that can back up qualitative research findings. Lewis et al.'s (2016) study is the only study that I am aware of that employs sophisticated quantitative and qualitative methods for the same research questions. However, Lewis et al. (2016) were unable to fully back up their qualitative results with quantitative analysis. This imperfect or at least vague conformity of the two research methods points towards a second methodological shortcoming, which is a potentially high degree of measurement error in self-reported data. For example, respondents might give overly enthusiastic statements when asked regarding the impacts of mobile phones. In the related body of literature concerned with effects of services delivered via mobile

phone (m-services), Baumüller (2015) and Fafchamps and Minten (2012), for example, found that self-reported effects may not necessarily live up to actual effects.

The third methodological shortcoming relates to those studies that quantify the impacts of mobile phone use. I am not aware of any experimental or quasi-experimental data on mobile phone use among pastoralists. The resulting lack of clear identifiability with purely observational data makes precise quantitative impact assessments difficult. I therefore view validations of existing claims or tests of new claims through experimental data—for example, through the use of randomized control trials (RCTs)—as valuable additions to the literature on mobile phone use.

RCTs require substantial time and capital investments by researchers, and RCT-based designs on mobile phone use among pastoralists may be particularly difficult: nomadic and seminomadic pastoralists frequently move, which may lead to high attrition rates. The widespread concept of sharing phones among pastoralists (Butt, 2015; Debsu et al., 2016) may additionally lead to substantial spillover effects. Nevertheless, RCTs regarding mobile phones in a rural African context are possible (see, e.g., Aker et al., 2016), if the design of the intervention is specifically adapted to this environment.

6 | CONCLUSION

Pastoral communities have experienced a rapid diffusion of mobile phone technology in recent years. Today, mobile phones represent an integral part of various activities and impact pastoralists' lives along several dimensions. Because the ability to communicate and access information is a vital necessity for most members of pastoral communities, mobile phone use is an area of research that deserves particular attention. Therefore, I identified, summarized, and analysed the emerging body of academic research concerned with this topic in order to connect existing case studies and determine common or divergent themes as well as aspects that are still underresearched. The exploratory review included 34 peer-reviewed articles. The findings of this body of research were categorized into six main themes, namely, income, herd management, health and nutrition, conflict, social change, and others.

The literature shows that pastoralists use mobile phones for several income-generating activities. This includes obtaining information on market prices of livestock, receiving remittances from family, friends, or business partners, and finding and managing alternative income sources. The literature also presents several ways in which pastoralists use mobile phones for managing their herds. Here, the more important use of the technology relates to access and provision of information related to forage and water resources, weather conditions, the location of rangers who might disrupt herding practices or to communicate quickly in situations that require veterinary assistance. A lack of trust towards the reliability of some information obtained through the mobile phone, however, reduces the usefulness of mobile phones as a tool to manage herds. Mobile phones also improve human health care and nutrition among pastoral communities. Health and other social services can be targeted better due to mobile phone-based health and surveillance systems. Moreover, pastoralists use the mobile phone to contact medical assistance quickly during urgent types of health crises. Mobile phones also improve diets in pastoral communities, because the phone can be used to access markets for food purchases, as well as to obtain information on times and places of food aid deliveries.

The effects of mobile phone on conflicts are ambiguous. On the one side, quicker communication enabled through mobile phone technology helps prevent or reduce some conflicts, such as human–wildlife conflict, or conflict between pastoralists and sedentary farmers. On the other side, the mobile phone may also exacerbate conflicts, for example, when phones are used by pastoralists to organize illegal grazing inside protected areas, or by raiding parties to avoid police or military outposts. The effects of mobile phones on social relations within pastoral communities is ambiguous as well. So far, men are gate keepers to mobile phone use by women, and consequently, mobile phones have for the most part not led more female empowerment. The phone may even be used by men to further disempower women. The literature also presents several channels through which the mobile phone contributes to the preservation and development of pastoral traditions and identity.

However, this review also identified a few important research gaps, as well as methodological shortcomings. Mobile phones' effects on pastoralists' income and expenditure, potential environmental externalities, and the influence of phones on gender roles are not yet sufficiently understood. More research on these topics is therefore encouraged. As a key methodological recommendation, research on mobile phone use among pastoralists based on primary data should take greater care regarding sample design, because people of pastoral communities who are difficult to reach either because they live in remote areas or because they are marginalized by the society should have equal chances of participating in a study. Because research on mobile phone use among pastoralists is highly relevant for policy makers and development practitioners, higher external validity through more inclusive sampling strategies could certainly lead to better policy and project designs.

ACKNOWLEDGEMENTS

This research was financially supported by the German Research Foundation (DFG) through the GlobalFood Program (grant number RTG1666). I thank Jacob Steckel for his research assistance and the two anonymous reviewers for their helpful and constructive feedback.

Open access funding enabled and organized by Projekt DEAL.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

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ENDNOTES

[1] Own calculations based on Afrobarometer survey data cover the countries Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Côte d'Ivoire, Egypt, Gabon, Ghana, Guinea, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, São Tomé and Príncipe, Senegal, Sierra Leone, South Africa, South Sudan, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

[2] Lewis et al. (2016) is an exception. They employ qualitative and quantitative assessments of the effects of mobile phones on incidents of human–wildlife conflicts.

[3] The sources of conflict regarding protected areas are manifold. A detailed discussion however goes beyond the scope of this paper. Interested are kindly directed to Butt (2012).

[4] More information on chances and difficulties regarding data collection via mobile phone in Africa is presented by Dillon (2012) or Hoogeveen et al. (2014).

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How to cite this article: Parlasca MC. A vital technology: Review of the literature on mobile phone use among pastoralists. *J. Int. Dev.* 2021;33:780–799. https://doi.org/10.1002/jid.3540