Perceived impacts of climate change on rural poultry production: a case study in Limpopo Province, South Africa

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Abstract

Rural farming households in developing countries frequently contend with multiple challenges, including a lack of resources, food insecurity, and poverty. Climate change threatens to compound existing challenges, particularly in such rural subsistence economies with limited adaptive capacity. We aim to establish farmers' perspectives on likely impacts of climate change on their rural poultry production in northern South Africa. A baseline questionnaire-based study was conducted across 106 households in the town of Musina, South Africa. Most households lacked reliable and adequate sources of income and had, for example, days when they had to skip meals as a coping strategy. With such poverty, coupled with poor access to scientific information on agricultural production, these farmers typically have limited capacity to adapt to shocks such as climate variability and change. Farmers reported a reduction in poultry productivity in recent years, coinciding with increased ambient temperatures. There are concerns that recent and ongoing warming trends will have negative impacts on the future growth and wellbeing of birds. However, the farmers in our study perceived their poultry as hardy and well adapted to survive any future climatic changes and may be uninclined to take adaptive action at this stage.

Keywords: Heat stress; Household; Productivity; Village chickens; Climate warming

1. Introduction

Subsistence and smallholder farming typically produce crops and rear livestock with minimal inputs. Such practices significantly contribute to the alleviation of poverty in rural areas of most low-income countries (Hachigonta et al., 2013; Mapfumo et al., 2014). Although smallholder farming is estimated to contribute 60 - 66% of food consumed in sub-Saharan Africa (Mapfumo et al., 2014), minimal or limited input into crop and livestock production results in relatively low agricultural productivity over the continent, frequently exacerbating low income, poverty, and food insecurity (Hachigonta et al., 2013). Observed and projected changes in climate further threaten to negatively impact this agricultural sub-sector. Smallholder farmers are inherently vulnerable to climate change, as they depend on natural resources and direct weather inputs (i.e. rainfall rather than irrigation) for production (Shisanya & Mafongoya, 2016), and do not have the infrastructure and technology in place to protect themselves and their livestock from climate extremes, including increasing temperatures (Hachigonta et al., 2013). Recent climate-warming trends during the past few decades (Cattaneo & Peri, 2016; Furlong & Zalucki, 2017) and anticipated temperature increases for southern Africa (DEA, 2013; Stocker et al., 2013), are expected to exacerbate incidences of heat stress (Engelbrecht et al., 2015).

Most smallholder farmers in rural areas of developing countries rear poultry, especially village chickens (see Figure 1), as a side-line food resource and income generating activity (Kingori et al., 2010; Malatji et al., 2016; Mulualem, 2016; Padhi, 2016). Village chickens, comprising mainly of nondescript breeds, are also referred to as 'rural', 'backyard', 'indigenous', 'scavenging', 'traditional', 'local', 'native' or 'family' chickens based on the typical smallholder production system in which they are produced (Moreki, 2010). These birds occasionally supplement household protein supply in the form of meat and eggs. They are considered a delicacy and may be slaughtered for special guests and functions (e.g. cultural activities and traditional wedding ceremonies). In cases where cash is urgently required, rural poultry is particularly valuable, as chickens are relatively easy to sell compared to other more expensive livestock, such as cattle (Nyoni & Masika, 2012).

Figure 1. Example of village chickens produced by smallholder farmers in Musina. Photo by Njongenhle M. B. Nyoni.

Despite the essential role that poultry plays in rural households, several challenges, such as predation, theft, and disease may impede production (Malatji et al., 2016; Mulualem, 2016; Win et al., 2019). Climate change may aggravate existing challenges (Alade & Ademola, 2013), yet research on the impacts that climate change may have on rural poultry production remains limited. The first key step for effective adaptation to climate change is 'noticing' that climate has changed (Gbetibouo, 2009). To this end, it is important to establish farmers' perspectives on climate change, as perceptions will ultimately influence their willingness to adapt their farming practices. Poultry farmers who have experienced climate-related losses are more likely to implement multiple adaptive management strategies, such as provision of water, ventilation and the purchase of medicines (Saweda et al., 2019). However, these strategies incur financial costs that may not be a viable option for extensive poultry producers who rely on traditional practices, and who may be less aware of

Figure 2. The location of four villages that participated in the study within Musina Local Municipality, Limpopo Province, South Africa.

climate-related mortalities. While it is encouraging that a Nigerian cohort of poultry farmers showed high levels of climate change awareness and an appreciation for the potential negative impact of climate change on egg and meat production (>90% for both; Adesiji et al., 2013), we must

caution that more than half of this cohort employed intensive or semi-intensive management systems. Given that socioeconomic status influences climate change perceptions and adaptation options (Adesiji et al., 2013), it is important to understand the perceptions of poultry farmers managing resource-limited extensive production systems. Our study thus aims to establish rural farmers' perspectives on climate change, and its likely impact on poultry production in an impoverished rural setting of Limpopo Province, South Africa (Figure 2). Specific objectives of our study include: (i) assessing the importance of rural poultry on rural livelihoods; (ii) determining farmers' perceptions of climate change; and (iii) identifying perceived impacts of historic increases in temperature on rural poultry production. Our study contributes toward the generation of new knowledge (primarily indigenous), which may be of future value in the context of securing ongoing investments into the rural subsistence poultry sector, particularly by local governments and development practitioners, and ultimately to advance rural poultry production in the face of local belief systems and climate change (Liverpool-Tasie et al., 2019).

2. Materials and methods

2.1. Study site

This study was undertaken in selected rural areas of Musina Local Municipality in Limpopo (Figure 2), where many households rear poultry for subsistence purposes. This province is regarded as one of the poorest in South Africa, with several pockets of extreme poverty and inequality that significantly impact on semi-skilled and unskilled members of the adult population (Lehohla, 2012). Musina Local Municipality has four villages located within 25km of each other, which include: Madimbo, Malale, Domboni, and Tshikhudini. The region experiences mean winter minimum air temperatures of ∼8°C and mean summer maximum air temperatures of ∼32°C in the shade, but which may occasionally reach ∼45°C (Weather Atlas, 2020).

2.2. Selection of participants and procedure

Following approval from the Human Research Ethics Committee of the University of the Witwatersrand (clearance number H14/11/27), a total of 106 households were selected through purposive and snowballing sampling techniques. Only individuals who owned poultry and demonstrated willingness to participate, were considered. A cross-sectional questionnaire survey was used to establish the perceived relationship between climate change and rural poultry production. The questionnaire was translated into Venda by native speakers, and then translated back into English, to ensure comparability. Pre-testing of the survey instrument took place in Madimbo during November 2014. Questionnaire-based structured interviews were conducted at a range of levels, including households, key informants in villages (village heads), and agricultural extension officers at district level.

To establish the importance of rural poultry on rural livelihoods, a series of topics which included household circumstances, rural poultry dynamics (i.e. flock entries and exits), feeding, housing, health care and access to information on agriculture, were explored during the survey. Farmers' perceptions of climatic and environmental changes over the past three decades were also recorded. Topics covered included perceived changes in mean temperature, mean rainfall, fire occurrence and vegetation cover. This was followed by questioning farmers as to whether they had noted any temperature increases, and if so, any impacts it may have had on rural poultry production. In particular, respondents were requested to provide insights on the perceived changes on matters concerning the point of lay (maturity), number of eggs produced per hen, average clutches produced by each hen per annum, percentage hatchability,chick survival (%) and bird sizes. In addition, we gathered information on farmers' perspectives on historic changes in the seasonal prevalence of poultry parasites and diseases. The survey also explored access to information and sources of information, focusing mainly on production and health-related information, livestock markets and prices, as well as information on climatic data and seasonal forecasts.

2.3. Data analyses

Collected data were analysed using Statistical Analysis Software (SAS) version 9.3 (SAS Institute, 2011). Descriptive statistics on collected quantitative information such as demography of participants, rural poultry dynamics, management practices etc., were computed as percentages using Proc FREQ (frequencies). The median and interquartile range were used to show the centre of poultry flock distributions per household.

3. Results

3.1. Demographic description of participants and household circumstances

All identified households approached were willing to participate in the study. The majority of household heads were male (59%), married (65%) and literate (71%). Literacy was defined as the ability to read and communicate in writing. Education levels varied, with 40% having received secondary education.

Despite a wide range of income generating activities, almost half (48%) of the participants had no formal employment. Very few interviewees were full-time farmers, with most participants (77%) farming on a part-time basis. Government grants and remittances from off-site relatives contributed significantly to household incomes. A few (18%) households had some dependents (family members) living in the Musina Local Municipality town and nearby farms. Most family members were healthy, with no known chronic illnesses (93%) or disabilities (97%). Most households included able-bodied family members fit to work in agriculture-related operations (crop/livestock management). Although most farmers had adequate access to food, 11% of households faced difficulties in securing meals, and 8% went without a meal for an entire day, on occasion.

3.2. Access to agricultural production information

Most farmers had access to agricultural production information (80%). However, access to information relating to livestock markets and prices (11%), and weather information (i.e. climatic data and seasonal forecasts: 9%), was limited. The three main sources of information were indigenous/traditional knowledge systems (i.e. engaging relatives and local social networks), media (i.e. radio, television) and government extension services (Figure 3). Only 18% of respondents had access to production advice through the media – observing that most information received from conventional channels was neither timely nor reliable. Key informants (village heads and agricultural extension officers) acknowledged that there was limited capacity (i.e. finances and personnel) for local extension agents to effectively reach every farming household around Musina villages. Of the farmers that relied on indigenous knowledge systems for decision-making, the majority (87%) relied on traditional leaders and village elders for guidance, while the minority (13%) used their own observations and previous experience to make production decisions.

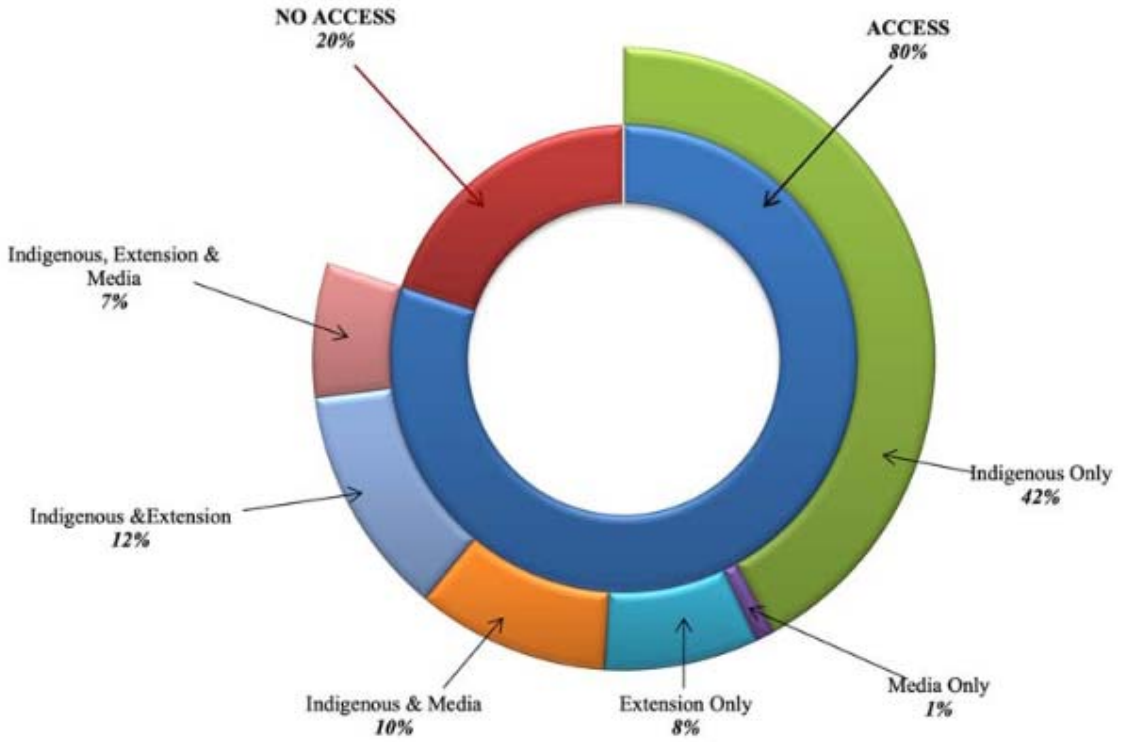

Figure 3. Farmers' access to agricultural production information in Musina Local Municipality, Limpopo Province of South Africa. The inner ring shows the proportion of farmers with access to agricultural production information, and the outer ring shows the sources of information. Here: Indigenous = "Indigenous/Traditional knowledge systems", Media = "Radio, Television, Newspapers etc.", Extension = "Agricultural extension officers".

3.3. Rural poultry housing, feeding and health care

A large number of respondents (59%) indicated that they supplied housing for their flocks. Rural poultry voluntarily sought housing at night, but spent the day scavenging for feed. Although some birds occasionally used poultry houses (i.e. seeking shade) as buffers against hot weather, housing mainly functioned as security against theft and predation at night. Housing structures were typically roofed structures consisting of using corrugated iron, the sides mostly (68%) fenced, and the natural ground compacted. Most farmers (84%) regularly (approximately 3–4 months) cleaned these structures and use the manure as fertilizer in their home gardens. In cases where shelters were not provided (41%), birds either roosted in trees or remained in open spaces overnight.

Most farmers (72%) provided non-discriminant supplementary feed to their flocks, with no special supplements for birds at different stages of growth. Supplements were provided erratically and varied widely across households, but mostly consisted of kitchen waste (primarily leftover starches: 46%). The majority (96%) of farmers also erratically provided tap water (almost daily) in small containers or non-conventional drinkers.

Health problems were reported to be common in rural poultry, largely thought to be related to both diseases and parasites (55%) – however, a considerable portion of farmers indicated that they experienced challenges related to diseases only (22%) or parasites only (21%), rather than both. Nearly half the respondents (48%) observed these health challenges to have fatal consequences. Many farmers (69%) undertook some form of control to combat such health challenges. Control methods (as a proportion of farmers that combatted health challenges) were highly variable and included conventional drugs (17%), for example antibiotics (Terramycin soluble powder, oxytetracycline HCL, Pfizer Animal Health) and insecticides (Karbadust dusting powder, carbaryl 5%,

Efakto), traditional practices (34%), or a combination of conventional and traditional remedies (49%). Traditional practices (ethno-veterinary control methods) were generally preferred because of their affordability (50%), accessibility and availability (29%), as well as perceived effectiveness (18%). Traditional practices commonly used for endoparasites included plants (*Aloe marlothii* and *Solanum panduraeforme*) and other locally derived remedies (e.g. chilli pepper and salt water), while ash was commonly used for ectoparasites.

3.4. Rural poultry flock dynamics and perceived changes

Most poultry owned by farmers in this study, were classified as 'village' chickens, with a median of 10 birds per household (interquartile range of 8–17 birds). Village chickens were primarily kept for consumption (egg and meat) and occasionally sold to generate petty cash. At the time of data collection (2015), the price obtained per bird was ~R50 (~US$3.31), but prices ranged from R30-R80 (US$2.03-US$5.42), depending on bird size and the farmers' financial need. Although some farmers considered breed (28%) and colour (20%) when selecting chickens for breeding stock, most (52%) were interested in bird size, which would enhance consumption quantity and selling price.

Farmers consumed about 20% of eggs per clutch at most, with the remainder being left for incubation by the hen. Hatchability, as a proportion of eggs not consumed, was 63% (i.e. 5 out of 8 eggs), of which about four birds survived to maturity. Chick losses reported were thought to be related to predation, theft and other unknown causes. Predators, such as raptors, were perceived to target chicks and growers, while adult birds were vulnerable to local theft. Despite these losses, three-quarters of farmers claimed that village chicken production was economically beneficial to them. Respondents attributed increases in the size of poultry flocks to hatchings (89%), gifts from relatives and neighbours (5%), purchases (4%) and loans from relatives and neighbours (2%), while decreases in the size of poultry flocks were attributed to mortality related to diseases (15%) and predation (28%), household consumption (33%), sales (14%), gifts to relatives (6%), loans to relatives and neighbours (3%) and theft (1%).

In addition to poultry, 38% of farmers owned cattle, 30% owned sheep, 59% owned goats, 26% owned donkeys and 28% owned pigs. Cattle, sheep, and goats were valued more than chickens, which is largely based on the income generated per livestock unit when sold. Numbers (herd size) of cattle, goats, and sheep were reported to have decreased by 40-50% over the past ~10 years, with such a decrease mainly attributed to disease and drought-related mortalities. However, village chicken production was reported to have declined by 20-30% over the same period (2005-2015). Perceived changes in village chicken productivity included delayed point of lay (by 47% of respondents), reduced number of eggs laid per clutch (by 54% of the respondents), decreased clutches per year (by 54% of the respondents), reduced hatchability (by 41% of the respondents), reduced chick survival to maturity (by 42% of the respondents), reduced bird sizes (by 44% of the respondents), as well as reduced flock size (by 71% of the respondents). Many farmers (45%) also suggested that the seasonal reproductive behaviours of birds had changed. In particular, it was highlighted that the laying routine has changed, with chickens now laying a single clutch instead of two over the summer season. Respondents reported that each hen laid ~60 eggs in ~5 clutches per year (i.e. a single clutch in summer, winter and spring with an average of two clutches in autumn; with ~12 eggs per clutch).

3.5. Perceived environmental and climatic changes, and related impacts on rural poultry

All interviewees acknowledged some form of environmental changes over the last three decades, with some variations in perceived changes. Perceived changes included increased temperatures, increased occurrence of droughts (including erratic and decreased mean rainfall), and decreased vegetation cover. Droughts were generally (91% of farmers) identified as a significant challenge for crop production. A third of farmers (34%) acknowledged that climate change would likely impede

future livestock production, with high temperatures potentially compromising egg-laying (i.e. quality and quantity) and, ultimately, rural poultry production. It is noteworthy, however, that no claims were made regarding previous or current impacts of increased temperatures on rural poultry farming. In fact, most farmers (96%) perceived their birds as hardy and well adapted to survive any extreme weather events.

4. Discussion

This study is the first to investigate farmer's perceptions of the impact that climate change may have on an extensive subsistence rural poultry production system. Understanding farmers' perceptions of climate change offers some insights into their preparedness and likely compliance with suggested intervention strategies (Tambo & Abdoulaye, 2013). The challenge, however, is that farmers' perceptions may vary or easily change in a given area, based on personal circumstances, available resources or circumstances in the community (Chingala et al., 2017; Gbetibouo, 2009), which in turn may influence production decisions (Bryant et al., 2000). For instance, the occurrence of a recent severe drought, as opposed to several recent years of above normal rainfall, may influence perceived ideas of climate change and the necessity to adapt. All farmers perceived increased temperature and aridity over the past 10–30 years and recognized a recent decline in rural poultry productivity. There was, however, no perceived connection between observed deteriorations in poultry productivity and climate change.

Several studies in other global regions have shown that farmers are generally aware of climatic changes and the associated potential impacts on agriculture, specifically crop production (Chingala et al., 2017; Harvey et al., 2014; Maddison, 2007; Yaro, 2013). In particular, perceptions of climate change are often well-aligned to recorded (quantified) climatic trends, especially concerning recent increases in temperature (Furlong & Zalucki, 2017; Gbetibouo, 2009; Nyanga et al., 2011). Indeed, annual and seasonal temperature trends in Limpopo Province have increased by up to 1°C since 1960 (Gbetibouo, 2009; Tshiala et al., 2011), which is well aligned and supports the qualitative information provided through indigenous knowledge systems.

Farmers in the Musina region highlighted the importance of rural poultry for their livelihoods, particularly as a source of food and income, which reinforces the value placed on poultry across much of Africa's rural subsistence economies (Kingori et al., 2010; Malatji et al., 2016; Mwacharo et al., 2013; Nyoni & Masika, 2012). With increased climate variability, it is likely that more households may become reliant on rural poultry as a practical and viable option to ensure food security.

Rural poultry farming in Limpopo, as in many regions across Africa (Malatji et al., 2016; Yemane et al., 2013; Yusuf et al., 2014), faces a range of production challenges, many of which relate to management practices (Muchadeyi et al., 2004). Rural poultry, predominantly village chickens, are usually kept by resource-limited farmers and are raised with minimal input (i.e. feed, housing and general health care: Aboe et al., 2006; Acamovic et al., 2005). These birds mostly scavenge for feed in their local environment to meet nutritional needs. Under scavenging systems, birds are susceptible to predation and theft (Biswas et al., 2008; Kusina et al., 2001; Pickworth & Morishita, 2007), hence the relatively high predation-related losses reported by Limpopo farmers. Incidences of theft seem low in the current study, especially in contrast to reports from Zimbabwe (Kusina et al., 2001; Muchadeyi et al., 2004), Ethiopia (Mulualem, 2016; Yemane et al., 2013), and other regions in South Africa (Malatji et al., 2016; Nyoni & Masika, 2012). Theft-related losses may, however, increase with increased demand for food (Tariq et al., 2014) and rising unemployment, as is the case in the Musina region.

In addition to predation and theft-related challenges, scavenging chickens are also prone to disease and parasitic infestation. Contact between flocks of different households, the exchange of birds as gifts or loans, sales and purchases, are key sources of disease transmission (Nyoni, 2011). Because village chickens roam freely in their local environment, there is also a possibility of disease transfer from other domestic fowls and wild birds (Acamovic et al., 2005; Nyoni, 2011). Climate change may exacerbate disease risk, both through an increase in the prevalence of particular diseases and as a result of disease vectors and parasites establishing themselves in new regions (Gale et al., 2010; Owoya et al., 2018; Semenza & Menne, 2009). Such indirect effects of climate change are likely to compound the direct effects of increased temperature, exacerbating heat stress in rural poultry (Lara & Rostagno, 2013).

Heat stress, resulting from extreme high air temperatures, is becoming increasingly prevalent in the Limpopo region (Maposa et al., 2021). Heat stress reduces feed intake and consequently compromises chicken growth and development, causing increased mortality. Temperature is thus considered the most important bioclimatic factor impeding subsistence poultry production (Thornton et al., 2009). Shade temperatures in Musina frequently exceed 30°C in summer, a temperature threshold known to cause heat stress in commercial breeds (Ilori et al., 2012; Tankson et al., 2001; Yahav et al., 1995; Ziervogel et al., 2014). Unlike commercial chickens that are bred for a high feed conversion ratio, which correlates with vulnerability to heat stress (Soleimani & Zulkifli, 2010), village chickens are considered 'hardy'. By scavenging outdoors, village chickens are regularly exposed to air temperatures that exceed 30°C with added radiant heat loads from direct sun. Village chickens may have acclimatized to these conditions (Soleimani et al., 2011). As a consequence of natural selection, local breeds are adapted to their environments (Romanov et al., 1996). Village chickens, like other indigenous livestock species (Besbes et al., 2007; Mtileni et al., 2012; Ngeno et al., 2014), may represent an important genetic resource that could be better adapted to local conditions than are commercial breeds. It is, however, possible that ongoing climate warming may expose chickens to even more extreme heat stress which may exceed their adaptive capacity.

Farmers reported a 20-30% decline in village chicken production during recent years, which coincides with the reported increases in temperatures and aridity over the last three decades. Perceived changes in poultry production includes phenological changes (for example a delayed point of lay) and reduced body size of birds. These responses are now so frequently reported in the literature, that they are considered "universal" ecological responses to climate change (Fenberg et al., 2016; Gardner et al., 2011; Van Buskirk et al., 2010; Visser & Both, 2005). Additional perceived changes to poultry production in recent years include a reduction in the number of eggs laid per clutch, reduced hatchability of eggs and reduced survival of chick to maturity, which may have contributed to the reduced flock size. Because ambient temperatures directly influence growth and development of birds (Lara & Rostagno, 2013; Mwale & Masika, 2009), it is likely that these responses are, at least in part, the consequence of increased temperature and aridity (i.e. declining rainfall) over the last few decades (MacKellar et al., 2014; Nyoni, 2018). Yet, unlike the Nigerian farmers who engaged in a variety of extensive and intensive poultry production systems (Adesiji et al., 2013), rural poultry farmers in Limpopo never explicitly linked perceived changes in poultry production with climate change.

A third of farmers acknowledged that future increases in ambient temperatures may compromise egg-laying (i.e. quality and quantity), which is not surprising given that heat stress is known to negatively impact egg production and decrease egg quality (Lara & Rostagno, 2013). For example, under conditions of heat stress, eggshell mineralization may be compromised as a result of decreased plasma calcium and respiratory alkalosis (Lin et al., 2004). Dietary supplements may prevent a decline in egg quality associated with heat stress (see Chung et al., 2005), however, rural farmers have limited recourses to invest in dietary supplements as an adaptive strategy.

Farmer inputs toward village chicken production are directly linked to the capacity of farmers to absorb external shocks. Analysing different dimensions of assets (natural, physical, human, social or financial) available to a household, explicitly exposes the relationship between household wealth and vulnerability to a given shock, such as climate change (Mapfumo et al., 2013). In our study, most farmers were poor, barely affording daily meals for their households. Thus, farmers are likely vulnerable to climate-related shocks, given that they lack the financial capacity to implement coping strategies (e.g. supplementary feeding). The vulnerability of farmers is also a function of access to important information related to agriculture and weather forecasts (Dutta, 2009; Ferris et al., 2014). Lack of adequate agricultural information is common in most rural settings, especially in developing countries with limited investments and few agricultural extension agents. As evident in this study, and others (Dutta, 2009), traditional (or local) knowledge systems are important to rural farming in developing communities. However, information received from local knowledge and network systems may vary within the same community, indicating unequal access to, or possibly distorted, information (Dutta, 2009). Future impacts of climate change will likely present adaptation demands that are beyond the scope of current local knowledge systems (Mapfumo et al., 2014). Thus, the use of indigenous/traditional knowledge systems may be limited in dealing with unique challenges (for example, heat stress and new diseases and parasites) that come with climate change (Baylis & Githeko, 2006; Thornton et al., 2009), potentially rendering rural communities even more vulnerable to climate shocks.

The role of an effective extension service in providing empirical evidence to smallholder farmers is critical for increasing agricultural productivity and food security in rural areas (Benjamin et al., 2016). Most farmers in the current study had limited access to conventional agricultural production information, and those that did, had little confidence in the information channels due to perceived lack of credibility. Active involvement of farmers in scientific research and development of relevant approaches within communities, has the potential to enhance uptake of agricultural and climate adaptation options required to improve agricultural productivity (Mapfumo et al., 2013). Such an approach also provides an opportunity for farmers and researchers to integrate local knowledge systems with new technologies and establish best adaptation options within the context of an unknown future.

5. Conclusion

Although rural poultry plays an important role in livelihoods of smallholder farmers in Musina as a source of food and income, farmers are faced with a plethora of challenges related to health and predation of their poultry. It is likely that climate change is exacerbating these existing challenges and directly causing heat stress to rural poultry. However, no cases of heat-related losses or mortalities were reported by farmers in the current study. Despite most farmers reporting a reduction in poultry production over recent times, coinciding with reported regional warming trends, the general perception was that rural poultry is “hardy” enough to cope with projected temperature increases. However, empirical evidence correlating climate warming with rural poultry production is still limited and requires additional research. Further, the extension of agricultural technical support is essential in helping farmers understand intricate climate change-related challenges and opportunities for improving rural poultry farming.

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