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REVIEW

Strategies of enhancing rural livelihoods and promoting sustainable use and conservation of indigenous chicken breeds in Zambia [version 1; peer review: 1 not approved]

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Abstract

This review explores innovative and sustainable strategies for conservation and use of village or indigenous chickens (IC) (*Gallus domesticus*) in Zambia and parts of Sub-Saharan Africa (SSA). Small scale farmers (SSF) have kept IC for hundreds of years to meet their households' nutritional needs, incomes, social-cultural and religious uses among others. The commitment exhibited by SSF in keeping IC has made them the major custodians of essential animal genetic resources in low-income regions. Between 1991 and 2012, private breeders invested over US\$95 million in Zambia's commercial poultry sector resulting in over 100% increase in annual production of day-old chicks to 65 million. However, high production cost and low market access hindered the participation of SSF hence their continued dependence on IC. Unfortunately, the future of IC genetic resources is threatened due to the rapid loss and erosion of IC breeds. In the 2015 biodiversity status report, the Food and Agriculture Organisation, an international body of the United Nation highlighted that over 3.5% of IC breeds were extinct, nearly 33% were at high risk and over 67% were of unknown status. Poultry diseases, lack of sustainable conservation strategies and poor use among others have significantly contributed to these losses. For example, in 2012, 60% of IC were diseased in parts of SSA including Zambia. If these challenges are not mitigated, the loss of IC genetic resources and the adverse impact on rural communities are inevitable. Further, future research and breeding programs on commercial chickens may also be limited as a result of erosion of IC genetic resources. Therefore, this paper reviews and contributes to previous studies that demonstrated how

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researcher-community-stakeholder engagements potentially enhanced sustainability and the adoption of innovative ideas including the potential to increase conservation and sustainable use of local chicken biodiversity in Zambia and parts of SSA.

Keywords

Animal genetic resource, biodiversity, conservation, rural-community, small-scale farmer, poultry-sector

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Introduction

The loss of indigenous chickens (IC) (*Gallus domesticus*) animal genetic resources (AnGR) and the low socioeconomic gains by the small-scale farmers (SSF) producing IC are the main threats to the livelihoods of rural communities in Sub-Saharan Africa (SSA). The Food and Agriculture Organisation (FAO), an international body of the United Nations reported in their biodiversity status report of 2015 that over 3.5% of IC breeds were extinct, 33% were at high risk and over 67% were in the unknown status category (FAO 2019). In SSA, 80% of SSF keep IC, significantly contributing to the indigenous poultry sector (IPS), making them the major custodians of IC-AnGR in the region. However, despite this important role they play, SSF have not realised significant socioeconomic gains from the IPS. Challenges such as poultry diseases, poor nutrition, and low access to markets are in part the cause of the current status of the IPS in Zambia and parts of SSA. Therefore, the main objective of researcher-community-stakeholder (RCS) engagements and potential innovation targeting SSF is to promote sustainable utilisation and conservation of IC-AnGR, through identifying major challenges and opportunities in the IPS and designing adoptable interventions.

Many countries in SSA experience varying and distinct agro-ecological conditions. The region's diverse climate affects individual countries in a variety of ways. In this scenario, Zambia is not exceptional. With a total surface area of 752,618 square kilometres (75.3 million hectares), Zambia is divided into three different agro-ecological regions (AER; I, II and III) each with unique agricultural challenges, concerning annual rainfall (ARF), vegetation, annual temperatures, soil type and water resources. The AER I and II occupy 54% of the total national land, mainly in the Southern, Western, Central and Eastern areas of Zambia (Phiri and Mukelabai 2010). These two regions receive between 800 mm and 1000 mm ARF, whereas region III, primarily in the Northern and North-western, classified as high rainfall zone, covers 46% of the total national area and receives more than 1000 mm ARF. Despite this variability in climate experienced across the country, and the fact that over 40% of fresh groundwater in Southern Africa is in Zambia, 90% of SSF practise rain-fed agriculture (Hamududu and Ngoma 2019).

Globally, most problems experienced in agriculture are highly associated with climate variations, which may worsen by the next century. Some studies predict that by the end of the 21st century, there will be a 3 °C increase in global temperature, 0.6% reduction in ARF, and 13% reduction in available groundwater due to climate change (Pelletier and Tyedmers 2010; Hamududu and Ngoma 2019). The drastic climate variation will have a more adverse effect in low-income countries, especially in SSA. Therefore, small livestock, such as goats, sheep and poultry, generally considered low input enterprises, are essential, and will contribute substantially to improving livelihoods among rural communities (Simainga *et al.* 2011; Queenan *et al.* 2016).

Guèye (1998, 2000) highlighted that IC, which comprises the majority of rural farming poultry (RFP) in SSA, have been kept by SSF for generations to meet their food security, household incomes, poverty reduction and empowerment of women. Some researchers have also documented how small livestock could help farmers become more adapted and resilient to climate variations than they would with larger livestock species. In fact, large animals, such as cattle, demand more grazing land and water resources (Yayneshet and Treydte 2015). This paper highlights the role of agriculture, indigenous poultry, challenges faced and what feasible strategies to mitigate the impact of the loss of IC-AnGR on rural communities in SSA. Throughout this paper, the term indigenous poultry will refer to indigenous chickens (IC) (*Gallus domesticus*) or village chickens excluding other domestic avian species. Further, all prices for poultry inputs and products are in the United States of America dollar (US\$).

Agriculture and indigenous chickens

According to FAO, chickens are globally classified in the top five crucial animal species, with the other four being cattle, sheep, goats and pigs (FAO 2019). Therefore, FAO has made it mandatory for countries to prioritise the submission of biodiversity status reports for the animal species highlighted above. Among the poultry species, IC have the highest population and importance in SSA, because most rural farmers produce these chickens at low land, capital and labour requirements. Although rural farmers practise low input production systems, there are variations in conditions and environments across the region and within countries based on their socioeconomic status (Guèye 1998, 2000). Studies thus far have revealed the socioeconomic function of IC for rural communities in low-income countries (Dolberg 2007; FAO 2019).

Despite researchers sharing a consensus on the socioeconomic role of IC in SSA, there are fewer attempts to holistically find solutions to challenges faced in the IPS including the continued loss of IC-AnGR and low socioeconomic gains by SSF (Dolberg 2007). The Poultry Association of Zambia (PAZ) expressed similar concerns regarding obscure solutions for SSF in Zambia's poultry sector. Generally, the problems faced by IPS are also associated with unsustainable use of IC-AnGR, lack of skills in animal management and disease control, absence of value addition among others (Guèye 2000; Mueller *et al.* 2015; PAZ 2021). Therefore, interventions that promote the sustainable development of the IPS need to be initiated to secure IC breeds and enhance rural livelihoods in Zambia and parts of SSA.

Studies have demonstrated that researcher-community-stakeholder (RCS) engagements could significantly improve the management of indigenous livestock, increase incomes and reduce poverty in low-income countries (Mueller *et al.* 2015). In their analysis of various community-based breeding programs (CBBP), Mueller *et al.* (2015) showed a positive impact of RCS engagements on AnGR and livelihood for SSF. The involvement of rural communities in CBBP empowered SSF through decision making and livestock business ownership. Most importantly, researchers found that CBBP was a sustainable option for conserving local AnGR through sustainable use and continuous improvements among SSF. There are fewer reliable long-term approaches suitable for rural communities, particularly in low-income countries (Mueller *et al.* 2015). However, to promote conservation of IC-AnGR and enhance the socioeconomic gains for SSF involved in IPS, developing an innovation based on the local context is essential. The community-based intervention aimed at developing the IPS through guidelines and principles of RFP by Guèye (2000), conservation of AnGR by FAO (2019), and the CBBP promoted by Mueller *et al.* (2015), would potentially help in identifying challenges and designing sustainable solutions within the Zambian local context.

Therefore, a collective approach based on shared interests among researchers, communities and stakeholders would create sustainable and adoptable strategies through a community-based indigenous poultry development program (CBIPDP). In the section below, details of the roles of agriculture and IC, constraints in the IPS and the developmental stages of CBIPDP through RCS engagements in Zambia and parts of SSA are covered.

Use of agriculture and indigenous chickens among rural communities

Agriculture has to address four main issues, namely increased cost of living, population growth, poverty and inequality. Most studies have demonstrated that agriculture provides employment, food and nutritional security, livelihood assets, and gender equality among rural communities, potentially countering the highlighted concerns (Guèye 2000; Dolberg, 2007; Boland *et al.* 2013). Globally, agriculture contributes 40% of gross domestic product (GDP) and provides employment to over 1.3 billion inhabitants (White 2012; Boland *et al.* 2013). A majority of SSF in low-income countries consider agriculture as a full-time occupation. For many generations, rural farmers in SSA have grown various crops and kept livestock, including IC for their livelihoods (Guèye 1998, 2000). Therefore, as we head towards the year 2050, agriculture and livestock production are crucial for job creation and meeting the food and nutritional demands in SSA (Klingholz 2020).

There is a consensus among researchers that IC and other indigenous livestock play significant socioeconomic and socio-cultural-religious roles among rural communities particularly in SSA (Lebbie and Ramsay 1999; Guèye 2000; Aklilu *et al.* 2007; Duguma, 2009; Queenan *et al.* 2016; Alders and Pym 2019). Small scale farmers keep over 80% of IC in the region (Guèye 1998, 2000; Queenan *et al.* 2016). Further, Guèye (1998, 2000) highlighted the value and relevance of IPS in SSA as far back as 1994. During this period, SSA had over 1.1 billion IC, producing over 1.7 million metric tonnes (MT) of eggs and 2.1 million MT of chicken meat compared to only 16 million ducks, producing over 26 thousand MT of duck meat and seven million turkeys yielding over 54 thousand MT of turkey meat. Further, analysis of surveys conducted in SSA showed that in 1994, each rural household kept up to 20 chickens, equivalent to three chickens for every two people in the rural human population (Guèye 1998). Changes in IC population in comparison to national poultry population for the period 1989 to 2018 for selected countries in SSA have been reported by FAO stat (2021) and Guèye (1998). For example, in Kenya, Malawi, Nigeria, Tanzania, Zimbabwe and Zambia the population for IC comprised nearly 80% of the national flock.

In the past three decades, the numbers and uses of IC have increased minimally compared to commercial poultry among rural communities. The difference in the growth rate between the two poultry subsectors is highly associated with the production costs and shortages of feeds experienced in SSA, with SSF affected significantly (Guèye 2000; PAZ 2021). The case of Zimbabwe is different where a 67% contraction in the poultry industry was observed between 2007 and 2018 (FAO Stat 2021). This may be associated with political and economic problems the country passed through during the 2000 - 2001 land reforms implemented by Zimbabwean government.

In Zambia, the socioeconomic role of agriculture is equally evident, especially among rural communities. According to the Ministry of Fisheries and Livestock (MFL), nearly 18% of Zambia's GDP is from agriculture, supporting over 12 million people and absorbing over 67% of the labour force (MFL 2017). Poultry is a significant component of agricultural GDP in Zambia. A study conducted in 2012 found that over one million smallholder poultry farmers out of 1,418,000 agricultural households surveyed raised over 12 million IC in Zambia (Lubungu and Mofya 2012). The study also found that half of the reported number of IC were owned by SSF in Eastern, Southern and Central provinces whereas the other half was distributed among the seven regions. The MFL estimated a 20% annual growth in IPS between 2012 and 2017 (MFL 2019).

Uses of indigenous chickens in Sub-Saharan Africa

In SSA, IC are highly valued among rural communities. The rural farmers use IC for household food source, income, breeding and incubating eggs, socio-cultural and religious functions among others (Guèye 1998, 2000; Moreki *et al.* 2010). The culture and socioeconomic status of the rural communities influence the diverse uses of IC observed across the region and within countries. However, the most common uses for IC are consumption, household income and social-cultural and religious roles.

Food source

Rural communities in SSA have kept IC for the animal-based protein requirement by consuming chicken meat and eggs. The contribution to food needs for rural households from poultry is much more significant compared to other types of livestock. For example, Guèye (1998, 2000) demonstrates how a simple farmer in Tanzania starts with one pullet and makes massive gains of close to 170 chickens - cocks, hens, pullets and cockerels, 440 to 1,100 eggs and 47 kg of chicken meat in five years, significantly improving the farmer's food security and general livelihood. In addition, past production trends in the IPS of selected countries in SSA also demonstrated how valuable IC were as food source. For example, between 1984 and 1989, this sector produced 23,117 MT eggs (12%) in Nigeria, 3,172 MT eggs (26%) and 14,835 MT meat (69%) in Ivory Coast, 396 million eggs (36%) and 29,952 MT meat (26%) in Morocco, and over 46 million eggs (71%) and 8611 MT meat (72%) in Kenya (Guèye 1998, 2000). The production in the IPS is expected to have grown exponentially to date.

The dynamics of consumption and use of IC in SSA are strongly associated with culture, socio-economic status and likely so by human population growth three decades from now (Guèye 1998, 2000; Klingholz 2020). For example, in Tanzania, the SSF consumed less than a half of what they produced, and sold the rest to rural areas, whereas in Zambia, the SSF consumed more than half of IC and only sold 20% to urban areas (Queenan *et al.* 2016).

Household income

Generally, IC have low input requirements depending on the socio-economic status of the rural farmers. However, IC are considered an easy way out of poverty because poor communities are more likely to own and farm them. These quick and easy socio-economic gains explain why these chickens are an entry point to wealth because anyone could start keeping them regardless of their socio-economic status (Guèye 1998, 2000; Dolberg, 2007). Indigenous poultry contributes to household incomes and assets that help improve livelihoods for SSF. Rural communities raise much-needed revenue for their household from chickens' sales to meet their daily household needs, including possible future investments. Guèye (1998, 2000) explained how SSF allocated incomes to various household needs. For example, when family A raises US \$180 from selling 30 chickens, they would spend it as follows: US\$72 for daily household needs, US\$54 for buying clothes, invest \$36 in business, and use US\$18 for purchasing replacement stock. The meticulous allocation of incomes from IC highlights their value to rural livelihoods. Farmers also use IC as a medium of exchange in form of barter system. For example, in the Gambia, SSF exchanged five full-grown hens with an adult sheep and 25 hens with one adult cow (Guèye 1998, 2000). This trend also illustrated how owning IC was as good as owning any other livelihood assets among SSF.

Gender empowerment

Indigenous chickens are gender and socio-economic equaliser supporting women and children in most parts of SSA (Kitalyi 1998; Guèye 2000; Morek *et al.* 2010; Simainga *et al.* 2011; Queenan *et al.* 2016). In SSA, the socio-economic value of indigenous poultry in empowering women was evident, as over 70% of IC were owned and managed by women and children in the region, which enabled them possess livelihood assets (Guèye 2000; Dolberg 2007). However, Dolberg (2007) pointed out that the physical asset was missing from the IC's livelihood equation in that – farmers could not harness animal draft power from chickens. Nevertheless, studies by Guèye (2000) demonstrated that farmers could buy or exchange IC with any assets they desired including cattle as was the case in the Gambia.

Some researchers viewed the subject of women empowerment through IC cautiously. For example, in certain societies in Tanzania, women and children could only manage the chickens, but the powers to decide on the marketing and use were still in men's hands (Queenan *et al.* 2016). Similar findings were examined in Mozambique where prolonged wars significantly reduced the number of cattle and goats resulting in increased interest and control of IC by men (Guèye 1998, 2000).

Social-cultural-religious uses

Some social-cultural and religious functions of IC among rural communities are usually a combination of incomes, consumption, gifts, medicinal and other uses. In SSA, rural communities sacrificed IC during traditional ceremonies and rituals, share cocks as gifts to their guests at cultural events, use the cocks for traditional medicines including sexual

stimulation for men, and also hygiene through scavenging (Guèye 2000). White feathered chickens are vital for traditional medicines and sacrifices in Somalia, Cameroon and Zambia. Attaching value to the colour or appearance of indigenous livestock is also a pricing technique under traditional markets in parts of SSA (Mueller *et al.* 2015).

Other uses

There are other uses of IC observed among SSF in SSA including incubation of eggs, security, ornamental and hobbies. For example, in Ghana, close to 71% of guinea fowls and IC were kept for breeding and most of the eggs incubated. Farmers, strategically selected desired males and females for continued production (Guèye 2000). Similarly, in Ethiopia, eggs were incubated and hatched for continued poultry production. Combined income and consumption use were reported in Zimbabwe, whereas in Nigeria, IC were also used for barter.

Zambia's poultry industry and challenges

In the 1990s, the Zambian government made economic reforms in the agriculture sector through a liberalised market system to promote private sector participation in delivering goods and services (Rakner 2003; Bonaglia 2009). During this period, most government-run entities were sold to private businesses. In 2005, a ten-year plan explicitly for the poultry sub-sector was established (Bagopi *et al.* 2014). The plan was aimed at increasing efficiency and productivity in the commercial poultry sector. The agriculture reforms and poultry sector plan led to an introduction of new genetics, improved nutrition, health and farming practices in the Zambian poultry industry. Within six years, both integrated and standalone breeders, such as Zambeef-Rainball, Pioneer-Bokomo, Tiger-Ross, Country bird, Panda and Hybrid were established (Bagopi *et al.* 2014; PAZ 2021). Further, a US\$95 million investment by Zambeef-Rainball breeders triggered unprecedented growth in the poultry sector. Between 2007 and 2012, there was an increase in the production of day-old chicks (DOC) from 27 to 65 million per annum with over 50,000 jobs created (Bagopi *et al.* 2014). Such changes observed in Zambia's poultry industry occurred much earlier in highly industrialised nations as observed in policies and the gains made by the consumers and the poultry industry in those countries (Steinfeld and Gerber 2010).

The other outcomes of economic reforms were the increased participation of SSF in the production of commercial chicken breeds, defying their conservative nature of keeping low input IC breeds (Bagopi *et al.* 2014; Mueller *et al.* 2015). The short production cycle and increased profits were among the reasons SSF were motivated to take part in the sector. However, because of anti-competition business practices exhibited in the poultry market structure and the rapid increase in production costs, smallholder broiler and layer producers failed to survive (Bagopi *et al.* 2014).

Production systems

The method used to produce chickens has a significant bearing on productivity and quality. The three systems of production practised by farmers are free-range system (FRS), where the chickens scavenge for feed, and no health care interventions used, the semi-intensive system (SIS), in which the chickens are partially allowed to scavenge, coupled with feed supplementation, and finally, the intensive system, in which the chickens are entirely confined and fed throughout their growth period (Guèye 2000; Okeno *et al.* 2013). Production methods such as FRS and SIS are perceived as beneficial to SSF, mainly due to negligible start-up costs, i.e. feeds and drugs (Guèye 2000; Queenan *et al.* 2016). Further, under FRS and SIS, chickens can roam and fend for themselves with minimal or no supplementary feeding by the farmer.

However, improving practices in areas such as disease control, shelter, marketing, feed supplementing and exploiting available feed resources may increase production efficiency and profitability among SSF in SSA (Goromela *et al.* 2006). Generally, SSF are at liberty to practice any of the three production systems depending on their constraints and socio-economic status (Guèye 2000). The intensive production system used mainly by commercial broilers and layers producers is unsustainable for SSF because of the high cost of production, disease prevalence, and the highly oligopolistic market controlled by big breeders and producers (Bagopi *et al.* 2014).

The cost of feeds and other live-inputs in the Zambian poultry industry generally increased in the past five years. In their weekly reports published for the first quarter for five years from 2016, the PAZ demonstrated that prices for solvent extracted soybean meal increased by 27.7% from US\$23.50 per 50 kg, whereas a 45.3% increase for broiler starter from US\$20.10 per 50 kg, 44% for broiler grower from US\$19.30 per 50 kg, 45.9% increase from US\$18.50 per 50 kg of finisher and a 49% change in price for layer mash from US\$14.70 per 50 kg in the period between 2016 and 2021 during which the average exchange rate was US\$1 to 12.95 Zambian kwacha (ZMW) (PAZ, 2021). Further, PAZ reported price increases for day old chicks for improved free-range chickens, layers and broilers by 87.5%, 83.3% and 125% from US\$0.80, US\$0.60 and US\$0.40 per bird, respectively. Other price changes included pullets, broiler, spent layers and IC increasing by 64.8%, 57%, 38.5% and 61.5% from US\$8.90, US\$3.00, US\$2.60 and US\$3.90 per bird, respectively (PAZ, 2021). The high costs of feed and other live inputs are the main reasons why SSF have failed to fully participate in commercial poultry production as these costs constitute the highest proportion of production costs.

Although some SSF attempted to produce commercial chickens from 2005 onwards, a majority of SSF continued with IPS by keeping IC because of the low but stable performance under FRS (Bagopi *et al.* 2014; PAZ 2021). Low costs, easiness of rearing and favourable prices of IC encouraged more SSF to consider IPS as potentially sustainable and profitable (Okeno *et al.* 2013; PAZ 2021).

Common indigenous chicken breeds

Farmers in the IPS rear different breeds of IC. The Ministry of Agriculture and Cooperatives (MACO) highlighted various IC breeds reared by rural communities in Zambia. The most common IC breeds among SSF include, the *common Zambian*, *Naked neck*, *Dwarfs* or *short-legged*, *Frizzled feathered*, *Feathery legged*, and *Short-tailed*, with live bodyweights (BW) ranging between 1.3 kg and 2.0 kg at over six months of age (MACO, 2003; PAZ, 2021). However, studies in Nigeria and Botswana suggest significant differences in live BW between female chickens (0.7 - 2.1 kg) and males (1.2 - 3.2 kg) (Guèye 2000).

Compared to broilers at six weeks, the growth period for IC is much longer. In the past few years, new breeds have also been introduced in Zambia's IPS. Some of these improved free-range chicken breeds, include the Boschvelds, Kruoilers, Black Australorps and Brahma. Although the improved free-range breeds are perceived to mature early and very productive under a free-range set-up, the high prices render them inaccessible to SSF. In general, the negligible costs involved in the production of IC promotes the continued farmer involvement in the IPS. A high benefit-cost ratio in IC is common as any selling price is regarded as profit (Simainga *et al.* 2011; Queenan *et al.* 2016). However, numerous challenges outlined in the sections below pose as major threats to IPS.

Threats to the indigenous poultry sector

Most rural farmers keeping IC are faced with several challenges with the potential to reduce the socio-economic benefits, which may negatively affect their livelihoods. These include, poultry diseases, poor policies, unstable markets and poor infrastructure.

Diseases and poor nutrition

The decision by SSF to reconsider the rearing of IC is a viable socio-economic strategy. However, poultry diseases and poor nutrition have been significant challenges in traditional poultry farming (Guèye 1998, 2000; Simainga *et al.* 2011). The argument is that the low input and scavenging production systems are less successful compared to the intensive system for broilers or layers. Uncontrolled poultry diseases and poor nutrition have made IC underperform compared to broilers in Zambia and parts of SSA. Research done in most low-income countries shows that a majority of SSF depend on natural remedies for controlling poultry and other livestock diseases. Guèye (2000) suggested that 79% of farmers used traditional herbs and plants to treat poultry diseases and that over 50% of mortalities happened under IPS by the first four weeks of chicken raising. In other parts of SSA, Queenan *et al.* (2016) reported that suspected Newcastle disease and fowl pox caused 40% to 100% mortalities in IC towards the end of the dry season.

In Zambia, the common diseases in the scavenging system include Newcastle disease, fowl pox, fowl typhoid, infectious coryza, Gumboro, helminthiasis, and ectoparasites, which have contributed to poor performance and high mortalities of IC experienced among SSF (Phiri *et al.* 2007; Simainga *et al.* 2011; Mubamba *et al.* 2018). In 2012, over 27% of SSF relied on traditional medication and less than 15% used veterinary drugs, resulting in 60% of the IC dying (Lubungu and Mofya 2012).

Despite the high disease prevalence observed in IC, there are beneficial adaptability and genetic gains through natural selection. The harsh environments in which indigenous livestock are reared leads to disease resistance and high adaptation to low-quality diets (Mapiye *et al.* 2008; Gizaw *et al.* 2010; Queenan *et al.* 2016). These traits which are more superior in IC than commercial breeds may be essential in future chicken breeding programs (Mapiye *et al.* 2008). Gizaw *et al.* (2010) suggest that adaptive traits are equal or more important than production traits in indigenous livestock production systems.

Nutritional challenges

Other nutritional concerns are the poor poultry feeding regimes among SSF. There is limited supplementary feeding and a lower plane of nutrition under the scavenging system, which ultimately leads to mortalities and reduced consistency in chicken (eggs) size and quality (Queenan *et al.* 2016). The majority of the IC are left to roam and scavenge for feed sources, such as insects, termites, vegetables, seeds, grains and earthworms and in rare situations, farmers supplement the chickens with kitchen waste, maize bran, leafy vegetables and other cheap feed sources (Mwalusanya *et al.* 2002; Goromela *et al.* 2006; Mapiye *et al.* 2008).

There are also variations in the availability of scavenged feeds depending on the time of year in Zambia. Village chickens have access to high protein insects and earthworms in the rain season (December to April), and high energy feed sources during the harvest of field crops in May to August, whereas, in the hot and dry season, a severe shortage of nutritious feed sources leads to poor health, malnutrition and high mortalities (Queenan *et al.* 2016). Dry seasons require feed supplementing to mitigate adverse effects on IC. In some parts of SSA, the breeding of black soldiers fly larvae and maggots as sources of protein are being experimented with and may improve nutrition in the IPS, especially in the dry seasons (Kenis *et al.* 2014).

Low policy support for indigenous poultry

A majority of SSA countries employ funding and infrastructure development plans favouring larger livestock species, predominantly run by commercial entities and minimal attention is given to IPS, despite SSF being part of the primary data source when designing policies on funding and infrastructure (Dolberg 2007; FAO 2019). These policies exacerbate the problems experienced in IPS and SSF feel that political leaders and scientists do not adequately represent them (Dolberg 2007). For example, recently, a livestock infrastructure support project funded by African Development Bank focused on the construction of dairy and beef infrastructure, whereas the Second National Agriculture policy of 2016 to 2020 did not adequately cover how value addition and market participation for SSF in IPS would be implemented in Zambia (MFL 2017).

Regulation on importation of poultry products

Poultry products worth millions of dollars are imported from overseas to SSA, negatively impacting both the commercial and IPS. In 2018, South Africa imported frozen poultry products of mixed parts valued at over US\$65 million from different sources in Brazil (PAZ 2021). These products lacked traceability, posed a public health threat and also affected the local poultry sector. In Ghana, over US\$60 million worth of poultry products were imported in 2018. These importations prompted the local poultry association to engage the Ghanaian government to introduce quotas on poultry imports in order to protect local poultry farmers. To mitigate the adverse effect of unfair trade, a ban on poultry imports was sanctioned in Namibia whereas, in Zambia, the poultry association engaged the government to promote policies that protect and enhance SSF in IPS (PAZ 2021). Some policy researchers recommend factoring in some livestock production policies and legislation on consumption to existing environmental management policies that could enrich strategies, enhance community benefits and reduce food wastage (Steinfeld and Gerber 2010).

Low access to formal and stable markets

In SSA, farmers in the IPS face barriers preventing them from accessing a formal market. These obstacles are associated with market standards and requirements, such as selling frozen whole or portions of chickens, packaging, labelling, and selling from standard outlets (Bagopi *et al.* 2014). Producers in IPS cannot compete with larger commercial entities because they neither own the required facilities nor the brands nor organised sales outlets (Simainga *et al.* 2011; Bagopi *et al.* 2014; Queenan *et al.* 2016). Further, the only way smallholder farmers can sell their chickens or eggs directly to established markets is through groups and intermediaries who manage most market channels (Bagopi *et al.* 2014). This way is also full of obstacles.

In Zambia, SSF sell chickens through informal markets, such as the roadside, village markets, backyard, and direct to consumers (Queenan *et al.* 2016; Mubamba *et al.* 2018; PAZ 2021). Recently, informal markets have transformed into essential selling points making it possible for farmers to organise and meet consumers' demands on quality and quantity. For example, the concepts of "Tuesday and Saturday markets" in some parts of the country have become popular. In the Northern part of Zambia, this traditional market is also called *Munada*, where traders agree on the date and place for the market day.

Generally, the low access to reliable markets affects the sales and consumption dynamics of IC among SSF. For example, in Tanzania, the SSF sold twice more village chickens and eggs to rural areas than they consumed and sold at US\$3.72 per live chicken, whereas in Zambia, producers of IC consumed more than half of their chickens and only sold 20% to urban areas at an average price of US\$3.37 per bird (Queenan *et al.* 2016). The variation in selling points and consumption levels shows how undefined and informal the markets in IPS is in parts of SSA.

Poor housing facilities

The lack of reliable poultry housing facilities for IC under scavenging systems is another constraint. Some IC are kept in undeveloped poultry houses at night to secure them from predators. However, in many cases, the chickens are left to hide in trees, making them vulnerable to predators, such as cats and dogs (Guèye 2000; Simainga *et al.* 2011). Consequently, theft, predation and environmental hazards are common, and significantly contribute to losses IC observed in the IPS. For example, a survey conducted in Western Zambia showed that 93% and 84% of the households interviewed attributed the losses to predation and thefts, respectively (Simainga *et al.* 2011).

Research application

Increased consumer demand for indigenous chickens

Despite the barriers and challenges experienced by SSF, IC are essential to both rural communities and consumers. In the past few years, the demand and preference for IC have steadily grown among consumers. The increased preference for IC results from the perceived good taste, fine texture, and health benefits of consumers, with some preferring male chickens for the large size and hens for their tenderness (Guèye 2000; Queenan *et al.* 2016). Although in South Africa, studies by Dyubele *et al.* (2010) found that consumers preferred broilers to IC due to tenderness and other attributes. Generally, the increased demand has led to a substantial rise in prices of IC over commercial chicken meat, potentially creating an opportunity for SSF (Guèye, 2000; Ajayi 2010; Queenan *et al.* 2016; PAZ 2021). For example, studies showed that, in Senegal, IC meat was sold at 27% higher than commercial broilers, while in Nigeria, the cocks were sold at prices over 300% more than the hens or broilers (Guèye 2000).

Similar trends have been observed in Zambia where the IC sell at nearly twice the price of broilers (PAZ, 2021). The Poultry Association of Zambia reported that, in 2016, live IC were sold at US\$4.0, which was 33% higher than broiler while in the first quarter of 2021, IC were priced at US\$6.40, which was 73% more than broiler chickens. During the period under review, on average, US\$1 was equivalent to ZMW12.95. This trend is consistent with some studies, where IC prices were higher particularly when sold in formal markets or places familiar to consumers (Guèye 2000; Queenan *et al.* 2016). Consumers want proof that what they are buying is indeed IC.

Population growth and food demand

Consumer demand for healthy products, including IC meat and eggs, will increase with human population growth in SSA. The United Nations, Food and Agriculture Organisation's revised projections show that from 2005 to 2050, the global human population will grow up to 9.2 and 9.8 billion, of which over 46% of growth will be in SSA, and a 60% increase in food demand is expected (Alexandratos and Bruinsma 2012; FAO 2019). During the same period, Zambia's population will reach 39 million, contributing to increased food requirements (Klingholz, 2020). Annual population growth of 1.9% in SSA with per capita food consumption of less than 2500 (Kcal/person/day) and annual undernutrition levels 20% higher than other regions was predicted for the period between 2005 and 2050 (Alexandratos and Bruinsma 2012).

Food consumption patterns

The population changes will significantly raise the food demand and consumption pattern of animal-based protein, which accounts for 40% of total protein consumed by humans (Lebbie and Ramsay 1999; Boland *et al.* 2013; Mueller *et al.* 2015). Some scholars also predict that the emerging of the middle-class will highly influence an increase in meat consumption in low-income countries, which will require applying technology and innovation to meet the demand during 'The Livestock Revolution' (Steinfeld and Gerber 2010). Globally, from 2000 to 2050, researchers predict an 82% increase in meat consumption, equivalent to 233 - 271 million MT of which 88 million MT is poultry and over 183 million MT from bovine, ovine and pig meat combined (Alexandratos and Bruinsma 2012; Boland *et al.* 2013). In other regions, meat consumption will increase at a slow rate, although the volumes demanded will be substantial, especially in SSA, where the farming population will get older and a majority will migrate to the urban areas as the middle class expands (Klingholz 2020).

Farmer mobilisation and sustainable interventions

To mitigate the future challenges on food and nutritional security, governments need to design sustainable agriculture programs, increase investment in research and promote sound policies that encourage the participation of youths in agribusiness and food production (Alexandratos and Bruinsma 2012; Klingholz 2020). In a few decades, SSF working in isolation in SSA may face more constraints as opposed to those working collectively. Farmer belonging to organised groups would improve production and productivity, achievable through good management, sustainable use and conservation of indigenous AnGR, improved disease control, improved nutrition and value addition (Livingston *et al.* 2011; Mueller *et al.* 2015; Queenan *et al.* 2016). Therefore, mobilising SSF into organised groups will significantly promote innovative RCS engagements and result in productivity and sustainability in the IPS in Zambia. The next section outlines examples of effective interventions emanating from RCS engagements in selected low-income countries.

Examples of community-based interventions

There are practical examples of RCS engagements and their impact on SSF as demonstrated by Rodríguez *et al.* (2011) and Mueller *et al.* (2015). These strategies resulted in socio-economic gains among rural communities that adopted various interventions in low-income countries. Mueller *et al.* (2015) outlined the process required when establishing

CBBP and gave examples of such approaches in developing countries that worked and those that faced challenges. These breeding plans had common features, including initiators being either the community or government research institutions, well-formulated breeding objectives based on indigenous or local breeds, the existence of institutional support (technical or financial) and each of the plans recorded a change (Rodríguez *et al.* 2011; Mueller *et al.* 2015).

Outcomes of CBBP

The analysis of various community-based interventions in low-income countries showed that support from research institutions and the government was crucial in achieving the set objectives. Further, the farmers worked together to identify and describe the problems to stakeholders. The impact of community-based interventions in low-income countries were empirically reported. For example, in Vietnam, pork farmers achieved between 40% and 100% increment in pork prices resulting from SSF working together with government institutions in identifying challenges and finding solutions, in Kenya, SSF experienced fast growth in goat population, and over 300% increase in goat milk yields from 0.25 litres per day after community-based solutions, where as in Ethiopia, positive testimonies and sharing of knowledge among SSF led to widespread adoption of sheep breeding strategies among rural communities (Mueller *et al.* 2015). Similar benefits of RCS interventions were observed in Benin where government and the community engaged in vaccinating IC and broilers against Newcastle disease and using improved poultry management resulted in 58% more profits from IC compared to broilers (Rodríguez *et al.* 2011). Like many community-based programs, RCS interventions are not spared from challenges. For example, in Bolivia, where the objective of the community-based intervention was improving the fibre quality of wool from llamas, politics, financial mistrust and funding challenges resulted to low sustainability (Mueller *et al.* 2015).

Challenges of community-based interventions and way forward

Generally, there are issues related to community-based interventions. Mueller highlighted trust, financial and technical problems that potentially affected sustainability and continuation of CBBP in some countries. These are important lessons worth considering when designing CBIPDP through RCS engagements for the IPS in Zambia. Promoting the voices and views of the target rural communities and understanding the local context is essential for designing sustainable community-based interventions (Patton 2010; Bryman 2016). For example, promoting poultry development plans based on exotic breeds, instead of indigenous species, is less valuable to SSF due to lack of adaptation new breeds to the local environment.

Some challenges associated with exotic breeds include low literacy, lack of records, diseases and high prices of breeds and costs of production for SSF (Mueller *et al.* 2015; Mtleni *et al.* 2016; Sebho 2016). Therefore, considering the local context, IC breeds, and promoting ownership of the intervention through RCS engagements is crucial to the sustainable conservation of IC-AnGR.

Selective adoption of workable approaches based on lessons learnt from IC-AnGR conservation and use would increase the chances of designing a sustainable community-based innovation targeting SSF in the IPS (Guèye 2000; Mueller *et al.* 2015; FAO 2019). For example, FAO outlined priority areas and interventions to promote the sustainable management and conservation of indigenous AnGR and enhancing livelihoods for rural communities as a global action plan.

The Food and Agriculture Organisation of the United Nations promoted five strategic areas on use and conservation of indigenous AnGR (FAO 2015, 2019). These are: (a) enhancing knowledge on characterisation of local animals, (b) develop sufficient institutional frameworks for AnGR management, enhanced linkages among livestock farmers, and stakeholders concerning policies and programmes, (c) Enhance awareness through education, training and research in significant areas of AnGR management, (d) Enhancing breeding strategies and programs to harness available genetic resources and match them with environments of production and requirements of societies and (e) Increase and diversification of conservation programs and possibly mix some approaches that use existing livestock breeds in the typical production environment and consider gene banks' use to store genetic materials. To implement the five areas, FAO required individual countries to undertake various programs towards the stated strategies and also expected to submit biodiversity status reports to the FAO Commission on biodiversity.

Zambia has implemented programs towards conservation of indigenous AnGR and promoting sustainability among SSF some of which partially fulfilled the five strategic areas of FAO. The programs planned and implemented through research and extension include; on-going farmer engagements and capacity building with donor support on climate-resilient projects, establishing livestock breeding centres across the country, promoting farmer driven innovation such community-based program on indigenous livestock, making available breeding technologies such as artificial insemination and embryo transfer among SSF through the National Artificial Insemination Services Centre in Mazabuka in

Southern province of Zambia. Through the African Union InterAfrican Bureau for African Animal Resources (AU-IBAR), Zambia formulated and launched the National Strategic Action Plan in 2018 - 2019 (NSAP) (MFL 2019). Specifically, NSAP was developed to promote sustainable utilisation and conservation of indigenous AnGR in Zambia.

Therefore, a sustainable IPS development plan based on understanding the production systems used by SSF, clearly defined roles of stakeholders and the importance of IC, has the potential to strengthen sustainable conservation of IC and enhance rural livelihoods. The evidence of success of RCS engagements in identifying problems and designing solutions indicates that adapting general practical principles from guidelines from RPF, FAO, and CBBP justifies why CBIPDP is a well-placed project for Zambia's IPS.

Conclusion

In conclusion, agriculture and small livestock including indigenous chickens have the potential to contribute to food and nutritional security, increased household incomes and access to livelihood assets for SSF in Zambia and parts of SSA, particularly towards the year 2050. To address concerns of the loss of IC-AnGR and the low socio-economic gains reported among SSF involved in IPS, CBIPDP is a workable research innovation strategy suitable for low-input agriculture production systems, common in Zambia and many parts of SSA. The CBIPDP would explore the integration of resources and skills through RCS engagements when formulating strategies to mitigate challenges in the IPS. Interventions such as improving farmer skills in poultry management, production, value addition and disease control may significantly contribute to SSF access to formal markets and enhance livelihoods for rural communities in Zambia.

Recommendations

Future studies should investigate market needs and consumption patterns for indigenous chickens among consumers in Zambia. Further, an assessment of the impact of the coronavirus disease 2019 (COVID-19) pandemic on the IPS is essential in understanding the resilience and sustainability of rural communities.

Data availability

No data are associated with this article.

Acknowledgements

The authors acknowledge the Deputy Vice-Chancellor of the University of New England in Australia, the Ministry of Fisheries and Livestock and the poultry industry in Zambia for supporting this work. Further, the authors extend the acknowledgement to both the Australian and Zambian governments for supporting research in agriculture, environmental and rural science.

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The manuscript entitled “Strategies of enhancing rural livelihoods and promoting sustainable use and conservation of indigenous chicken breeds in Zambia” discusses the importance of and ways to improve indigenous chicken production in Zambia. I think the effort is useful and provides a perspective on the role of indigenous chickens on resource-poor households in Zambia. I am, however, concerned about the organization, readability, and flow of ideas in the manuscript. The manuscript is difficult to comprehend and needs to be edited carefully. I encourage the authors to improve the manuscript after paying attention to the comments below:

- I suggest “Strategies of promoting sustainable use and conservation of indigenous chicken breeds in Zambia” as the title.
- Generally, although it is important to make the review of broad interest, the authors should avoid digressing. The topic and objective suggest that the review is on indigenous chicken production in Zambia, but the manuscript ended up covering the whole of Sub-Saharan Africa and even other countries such as Ghana, Senegal, Kenya, Gambia, Morocco, Nigeria, Tanzania etc. While it is important to compare indigenous chickens production in Zambia to other developing regions, it is more important not to lose focus.
- The authors need to find a logical structure for the review. There is no clear flow of ideas. For example, the introduction starts with a discussion/background on chicken production and then, in paragraph 3, the focus shifts to goats, sheep and poultry in general. The authors then go back to indigenous chickens in the last paragraph. Initial sections of the review were on indigenous chickens but broadened towards all livestock or, maybe, all indigenous livestock. Authors should find a logical way to order and link the sentences, paragraphs and sections of the review.
- The document has too many acronyms. This makes reading and understanding the manuscript difficult. Acronyms such as RPF, IC, RCS, IPS, SSF, AER, ARF, FRS and SIS can be

avoided.

- Throughout the document, some statements/facts are not backed by relevant citations.
- Paragraph 1, line 8 – “...IPS in Zambia and parts of SSA”. Is Zambia not part of SSA? Authors should also justify why the review focuses on Zambia in the same paragraph
- Paragraph 1, line 9 - “Therefore, the main objective of ...” should be changed to “Therefore, one of the main objectives of ...”
- The section entitled “Agriculture and indigenous chickens” focuses on chickens. Less, if anything, is on other agricultural practices. The title should be revised.
- Page 4, Paragraph 2 - Avoid starting a paragraph with the word “therefore”. Paragraphing in the manuscript needs to be improved. A paragraph should start with a “topic sentence” which introduces the idea to be discussed in the paragraph and the rest of the sentences in the paragraph should be linked to or be an expansion of the topic sentence.
- Page 4, paragraph 3 - What is the difference between this section and the preceding section?
- Page 4, paragraph 3, line 8 - Is livestock production not part of agriculture?
- Page 4, paragraphs 5 and 6 - Does this fit into the sub-topic “Use of agriculture and indigenous chickens among rural communities”? I also think the last three paragraphs on this page are more like repetition, or can fit well in previous sections.
- Page 5, paragraph 1 - What is the difference between this section and the proceeding one?
- Some of the references used on the production statistics are too old. Surely production statistics reported in 1989 and 1984 would have changed by now? Authors should use mostly young literature throughout the document. Some of the sections, e.g. paragraph 4, lines 7- 9, do not add value to the review and should be deleted.
- The last paragraph on page 6 can be summarised into one sentence.
- Page 7, paragraph 2 - The subtopic is incomplete. In Zambia? SSA? How does the last sentence fit into the paragraph? Any link with the preceding sentence?
- Page 7, paragraph 7 - The sentence “.... there are beneficial adaptability and genetic gains...” contradicts sentences in the preceding paragraph. If the chickens are adapted, then why is the mortality rate high?
- Page 7, paragraph 8 - Isn't this repetition? The preceding section also includes nutritional challenges (at least according to the section heading). Southern Africa is rich in supplements for indigenous chickens. Communal farmers grow crops such as sorghum, finger millet sunflower and millet which can be used to feed chickens. Some of these crops are drought resilient. Is nutrition really a big problem for indigenous chickens under

communal systems in Sub Saharan Africa? Maybe when it comes to commercialization of the indigenous chickens.

- Page 8

Revise subtopic "Low policy for...."

Some of the prices quoted were reported 5 years ago? Are the prices still the same now?

Authors may also comment on the issue of market linkages

- Page 9 - What is the link between the section on "research applications" and preceding linkages? The subtopic is also not clear. Does it reflect on the contents of the section?

Is the topic of the review discussed comprehensively in the context of the current literature?

Partly

Are all factual statements correct and adequately supported by citations?

Partly

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Sustainable livestock production

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 09 Apr 2022

Christopher Kanyama

RESPONSE TO REVIEWERS REPORT

This is the response to the reviewers report and guidance provided by Zindove T.J (2022) with reference to our review article entitled: Strategies of enhancing rural livelihoods and promoting sustainable use and conservation of indigenous chickens in Zambia [version 1].

On behalf of my fellow authors, I acknowledge receipt of the report and appreciate the valuable guidance provided by the reviewer.

We shall definitely consider the suggestions and guidance given with the aim of improving the quality of content to the required scientific standard.

Looking forward to future engagements.

Kanyama C.M

Corresponding author
(09/04/2022)

Competing Interests: No competing interests disclosed

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