REVIEW

Strategies of promoting sustainable use and conservation of indigenous chicken breeds in Zambia: lessons from low-income countries [version 2; 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 with lessons in 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. The commitment exhibited by SSF to keeping indigenous animals has made them the major custodians of essential animal genetic resources in most 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 the annual production of day-old chicks to 65 million. However, high production costs and low market access hindered the participation of rural farmers hence their continued dependence on IC breeds. The future of IC genetic resources is threatened due to their rapid erosion. In the 2015 biodiversity status report, the Food and Agriculture Organisation, an international body of the United Nations highlighted that over 3.5% of chicken 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 have significantly contributed to these losses. For example, in 2012, 60% of village chickens were reportedly diseased in parts of SSA. If these challenges are not mitigated, the loss of IC genetic resources and the adverse impact on rural communities is inevitable. Further, future research and breeding programs on commercial chickens may be limited due to the erosion of IC genetic resources. This paper reviews lessons and contributes to previous studies that demonstrated how community-based breeding programs and researcher-community-stakeholder engagements potentially enhanced sustainability, adoption of innovative ideas and conservation of local animal genetic resources in selected low-income countries. Further, suggest strategies to promote judicious use and conservation of IC breeds in Zambia.

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

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Introduction

Many countries in Sub-Saharan Africa (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. The country has a total surface area of 752,618 square kilometres (75.3 million hectares), divided into three different agro-ecological regions I, II and III, each with unique agricultural challenges concerning annual rainfall, vegetation, annual temperatures, soil type and water resources. The agro-ecological regions I and II occupy 54% of the total national land, mainly in Southern, Western, Central and Eastern areas of Zambia (Phiri and Mukelabai 2010). These two regions receive between 800 mm and 1000 mm annual rainfall. In contrast, region III, primarily in the Northern and North-western, classified as a high rainfall zone, covers 46% of the national area and receives more than 1000 mm annual rainfall. 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).

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 three degrees Celsius increase in global temperature, 0.6% reduction in annual rainfall, and a 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 on low-income countries, especially in SSA. Therefore, small livestock, such as goats, sheep and indigenous 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 indigenous chickens (IC) (*Gallus domesticus*), which comprises the majority of rural farming poultry 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).

The loss of IC, 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 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 (Scherf and Pilling 2015). In SSA, 80% of SSF keep IC, significantly contributing to the indigenous poultry sector, making them the primary custodians of IC-AnGR in the region. However, despite this critical role, SSF have not realised significant socioeconomic gains from the IC. Challenges such as poultry diseases, poor nutrition, and low access to markets are in part the cause of the current status of the indigenous poultry sector in SSA. Therefore, one of the main objectives of researcher-community-stakeholder engagements and potential innovation targeting SSF is to promote sustainable utilization and conservation of indigenous AnGR, identifying significant challenges and opportunities in the indigenous poultry sector and designing adoptable interventions.
This paper highlights the role of indigenous poultry, challenges faced and feasible strategies to mitigate the impact of the loss of IC-AnGR on rural communities in SSA. Further, suggestions on strategies to promote sustainable use and conservation of IC breeds in Zambia are outlined based on lessons learnt on the roles of indigenous poultry in low-income countries, application of interventions such as community-based breeding programs and researcher-community-stakeholder engagements in low-income countries. Throughout this paper, the term indigenous poultry will refer to IC or village chickens, excluding other domestic avian species. Further, all prices for poultry inputs and products are in the United States of American dollar (US$).

Roles of agriculture and the value of indigenous chicken genetic resources in low-income countries

Agriculture has to address four main issues: 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% to gross domestic product (GDP) and employs over 1.3 billion inhabitants (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 is crucial for job creation and meeting the food and nutritional demands in SSA (Klingholz 2020).

According to FAO, chickens are globally classified in the top five crucial animal species, with the other four being cattle, sheep, goats and pigs (Scherf and Pilling 2015). Therefore, FAO has made it mandatory for countries to prioritize 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 (Bett et al. 2013). 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; Scherf and Pilling 2015). Past and present research agrees on, socioeconomic and socio-cultural-religious value of IC to rural communities in SSA (Lebbie and Ramsay 1999; Guèye 2000; Akhlu et al. 2007; Duguma, 2009; Queenan et al. 2016; Alders and Pym 2019). Rural 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 the indigenous poultry sector in SSA as far back as 1994. During the period under review, 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, an 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 the 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 the country’s political and economic difficulties during the 2000-2001 land reforms implemented by the Zimbabwean government.

In Zambia, the socioeconomic contributions of agriculture are 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 agriculture in the country. 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 indigenous poultry sector between 2012 and 2017 (MFL 2019).

Uses of indigenous chickens among rural communities

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 benefits 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 than other livestock types. 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 indigenous poultry sector 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 indigenous poultry sector is expected to have grown exponentially to date.

Consumption levels for village chickens and related products depend on the performance of farmers’ chickens. Communities that experience higher chicken mortalities exhibit low consumption levels for eggs and chickens meat, as eggs are solely for hatching and replacement stock (de Bruyn et al. 2018). In contrast, chickens are for sale to raise household incomes (de Bruyn et al. 2018). Global consumption trends for poultry products show that from 2004 to 2012 a 9% increment in chicken meat to 63 million MT, and hen eggs rose by 20% to 55.5 million MT was reported (Scherf and Pilling 2015).

The dynamics of consumption and use of IC in SSA are strongly associated with culture, socioeconomic status and surely by human population growth three decades from now (Guèye 1998, 2000; Klingholz 2020; Scherf and Pilling 2015). 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 and considered an easy way out of poverty because poor communities are more likely to own and farm. These quick and easy socioeconomic gains explain why these chickens are an entry point to wealth because anyone could start keeping them regardless of their socioeconomic 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 allocate incomes to various household needs. For example, when family A raises USS180 from selling 30 chickens, they would spend it as follows: USS72 for daily household needs, USS54 for buying clothes, invest $36 for business and use USS18 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 socioeconomic 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 socioeconomic 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).

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 reported 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 (Scherf and Pilling 2015). In SSA, rural communities sacrificed IC during traditional ceremonies and rituals, shared cocks as gifts to their guests at cultural events, used the cocks for traditional medicines, including sexual stimulation for men, and hygiene through scavenging (Guèye 2000). White feathered
chickens are vital for traditional medicines and sacrifices in Somalia, Cameroon and Zambia (Guèye 2000). 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). Indigenous chickens are a bigger part of culture such that as people migrate to urban areas, they introduce their foods and animals (Scherf and Pilling 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 eggs were incubated (Guèye 2000). Farmers strategically selected desired males and females for continued production (Guèye 2000; Scherf and Pilling 2015). Similarly, eggs were incubated and hatched in Ethiopia for continued poultry production. Combined income and consumption use were reported in Zimbabwe, and in Nigeria, IC were also used for barter (Guèye 2000).

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 aimed to increase 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 day-old chicks production 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 increased participation of SSF, defying the conservative nature, in the production of commercial chickens was temporal due to high production costs and anti-competition tendencies they faced in Zambia’s commercial poultry sector (Bagopi et al. 2014; Mueller et al. 2015).

Poultry production systems in Sub-Saharan Africa
The method used to produce chickens has a significant bearing on productivity and quality. The three systems of production practised by farmers are the free-range system, where the chickens scavenge for feed, and no health care interventions are used, the semi-intensive system, 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 free-range and semi-intensive systems are perceived as beneficial to SSF, mainly due to negligible start-up costs, i.e. feeds and drugs (Guèye 2000; Queenan et al. 2016). 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 three production systems depending on their constraints and socioeconomic 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 most SSF continued with indigenous poultry sector by keeping IC because of the low but stable performance under free-range system (Bagopi et al. 2014; PAZ 2021). Low costs, easiness of rearing and favourable prices of IC encouraged more SSF to consider the indigenous poultry sector as potentially sustainable and profitable (Okeno et al. 2013; Bett et al. 2013).

Common indigenous chicken breeds
Farmers in the indigenous poultry sector 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 Zambi, 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) (Grève 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 indigenous poultry sector. Some of these improved free-range chicken breeds include the Boschvelds, Black Australorps and Brahmas (PAZ 2021). 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 (PAZ 2021). In general, the negligible costs involved in the production of IC promote the continued farmer involvement in the indigenous poultry sector. 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 the sector.

Threats to the indigenous poultry sector in Sub-Saharan Africa
Most rural farmers keeping IC face several challenges with the potential to reduce the socioeconomic 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 in Zambia to reconsider the rearing of IC is a viable socioeconomic strategy. However, poultry diseases and poor nutrition have been significant challenges in traditional poultry farming (Grève 1998, 2000; Simainga et al. 2011). The argument is that the low input and scavenging production systems are less successful than the intensive system for broilers or layers (Rischkowsky and Pilling 2007; Scherf and Pilling 2015). Uncontrolled poultry diseases and poor nutrition have made IC underperform compared to broilers in SSA. Research done in most low-income countries shows that most SSF depend on natural remedies for controlling poultry and other livestock diseases (Scherf and Pilling 2015). Grève (2000) suggested that 79% of farmers used traditional herbs and plants to treat poultry diseases and that over 50% of mortalities happened under indigenous poultry sector by the first four weeks of chicken raising. In other parts of SSA, Queenan et al. (2016) reported that suspected Newcastle disease and fowlpox caused 40% to 100% of mortalities in IC towards the end of the dry season.

In Zambia, the common diseases in the indigenous poultry 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). In SSA, the main factor responsible for the loss of indigenous AnGR includes disease and poor disease management at 28%, the introduction of exotic animal breeds, uncontrolled cross-breeding, and climate change at 22%, 63% and 16%, respectively (Scherf and Pilling 2015).

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). Among the 75 avian breeds that show unspecified resistance to Newcastle disease a devastating and infectious disease endemic to certain areas, 56 were chicken breeds (Scherf and Pilling 2015). In Nigeria, Naked neck and Yoruba chickens exhibited resistance to viral infection and eliminated the disease if occurred (Adewumi et al. 2012; Bobbo et al. 2013). Further, novels genes and the pathways signalling the resistance of avian influenza in poultry were analysed by (Wang et al. 2014). These traits, which are 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, leading 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 fluctuations in the availability of poultry scavenged feed resources between one harvest and the following year in rain-fed farming in SSA (de Bruyn et al. 2018). 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 from 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 (de Bruyn et al. 2018). In some parts of SSA, the breeding of black soldiers fly larvae and maggots as protein sources are being experimented with and may improve nutrition in the indigenous poultry sector, especially in the dry seasons (Kenis et al. 2014).

Inadequate policies in support of the indigenous poultry sector

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 the indigenous poultry sector, despite SSF being part of the primary data source when designing policies on funding and infrastructure (Dolberg 2007; Scherf and Pilling 2015). These policies exacerbate the problems experienced in the indigenous poultry sector 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 the indigenous poultry sector would be implemented in Zambia (MFL 2017).

Regulation on importation of poultry products

Low-income countries have witnessed economic growth, particularly from the private sector. The observed changes are motivated by inadequate regulations and policies that negatively affect ecosystems, AnGR, the poultry industry and markets (Scherf and Pilling 2015). Poultry products worth millions of dollars are imported overseas to SSA, negatively impacting the commercial and indigenous poultry sectors. 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 affected the local poultry sector. In Ghana, over US$60 million worth of poultry products were imported in 2018 (PAZ 2021). These importations prompted the local poultry association to engage the Ghanaian government to introduce quotas on poultry imports to protect local poultry farmers. To manage adverse effect of unfair trade, a ban on poultry imports was sanctioned in Namibia. In Zambia, the poultry association engaged the government to promote policies that protect and enhance SSF in the indigenous poultry sector (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 indigenous poultry sector 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 indigenous poultry sector 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, smallholder farmers can only sell their chickens or eggs directly to established markets through groups and intermediaries who manage most market channels (Bagopi et al. 2014; Queenan et al. 2016). 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” have become popular in some parts of the country (PAZ 2021). 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 markets for IC are in SSA.

**Poor housing facilities**

Another constraint is the lack of reliable poultry housing facilities for IC under scavenging systems. Some IC are kept in undeveloped poultry houses at night to secure them from predators. However, 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 indigenous poultry sector. 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 innovation and application**

Research innovations and applications should respond to the current and future food and nutritional security needs of rural farmers in SSA. Resilience and continuity of the indigenous poultry sector and rural communities partly depend on the deliberate engagements among researchers, communities and stakeholders (Scherf and Pilling 2015).

**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 (Bett et al. 2013). 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 IC meat was sold at 27% higher than commercial broilers in Senegal, 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 broilers, 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; Scherf and Pilling 2015). Zambia’s population will reach 39 million during the same period, 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 predicted for the period between 2005 and 2050 requires increased food supply in SSA (Alexandratos and Bruinsma 2012; Scherf and Pilling 2015).

**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 emergence 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; Scherf and Pilling 2015). In other regions, meat consumption will increase slowly. However, 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**

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 indigenous poultry sector, including the continued loss of IC-AnGR and low socioeconomic gains by SSF (Dolberg 2007). The Poultry Association of Zambia expressed similar concerns regarding obscure solutions for SSF in Zambia's poultry sector. Generally, the problems faced by the indigenous poultry sector are also associated with unsustainable use of IC-AnGR, lack of skills in animal management and disease control, and absence of value addition among others (Guèye 2000; Mueller et al. 2015; PAZ 2021). Interventions that promote the sustainable development of the indigenous poultry sector need to be initiated to secure IC breeds and enhance rural livelihoods in Zambia.

Studies have demonstrated that researcher-community-stakeholder 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) and Scherf and Pilling (2015) showed a positive impact of the researcher-community-stakeholder engagements on AnGR and livelihood for SSF. The involvement of rural communities in CBBP empowered SSF through the 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 and also a more reliable long-term approach suitable for rural communities, particularly in low-income countries (Mueller et al. 2015).

To promote the conservation of IC-AnGR and enhance the socioeconomic gains for SSF involved in the indigenous poultry sector, developing an innovation based on the local context is essential. The community-based intervention aimed at developing the sector through guidelines and principles of rural farming by Guèye (2000), conservation of AnGR by Scherf and Pilling (2015), and the CBBP promoted by Mueller et al. (2015), would potentially help in identifying challenges and designing sustainable solutions within the Zambian local context. 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).

To mitigate the future challenges to 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 (Livingston et al. 2011). 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 engagements of stakeholders and result in productivity and sustainability in the indigenous poultry sector in Zambia. The following section outlines examples of effective interventions emanating from engagements of prominent stakeholders in selected low-income countries.

**Examples of community-based interventions**

There are practical examples of Stakeholders’ engagements and their impact on SSF in low-income countries, as demonstrated by Rodríguez et al. (2011) and Mueller et al. (2015). These strategies resulted in socioeconomic gains among rural communities that adopted various interventions in low-income countries. Mueller et al. (2015) outlined the process required when establishing CBIPD 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 impacts 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 the goat population, and over 300% increase in goat milk yields from 0.25 litres per day after community-based solutions, whereas 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 stakeholders-based 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 than broilers (Rodríguez et al. 2011). Like many community-based programs, the researcher-community-stakeholders interventions are not spared from challenges. For example, in Bolivia, where the objective of the community-based intervention was to improve the fibre quality of wool from llamas, politics, financial mistrust, and funding challenges resulted in 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 the sustainability and continuation of CBBP in some countries. These are essential lessons worth considering when designing CBIPDP through engagement of the main stakeholders in the indigenous poultry sector in Zambia. Promoting the voices and views of the target rural communities and understanding the local context are 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 the lack of adaptation of new breeds to the local environment (Scherf and Pilling 2015).

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; Mùileni et al. 2016; Sebho 2016). Therefore, considering the local context, IC breeds, and promoting ownership of the intervention formulated through engagements of stakeholders 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 indigenous poultry sector (Guèye 2000; Mueller et al. 2015; Scherf and Pilling 2015). For example, FAO outlined priority areas and interventions to promote the sustainable management and conservation of indigenous AnGR and enhance livelihoods for rural communities as a global action plan.

The Food and Agriculture Organisation of the United Nations promoted five strategic areas on using and conserving indigenous AnGR (Scherf and Pilling 2015). These are: (a) enhancing knowledge on the characterisation of local animals, (b) developing 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 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 toward the stated strategies through formation of AnGR conservation committees and submit biodiversity status reports to the FAO Commission on biodiversity (Scherf and Pilling 2015).

Zambia has implemented programs to conserve indigenous AnGR and promote sustainability among SSF, some of which partially fulfilled the five strategic areas of FAO. The programs planned and implemented through research and extension include: ongoing farmer engagements and capacity building with donor support on climate-resilient projects, establishing livestock breeding centres across the country, promoting farmer-driven innovation such as community-based programs 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 (MFL 2019). Through the African Union InterAfrican Bureau for African Animal Resources (AU-IBAR), Zambia formulated and launched the National Strategic Action Plan in 2018-2019 (MFL 2019). Specifically, the action plan was developed to promote sustainable utilisation and conservation of indigenous AnGR in Zambia.

Therefore, a sustainable indigenous poultry sector 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 successes of researcher-community-stakeholders engagements in identifying problems and designing solutions indicates that adapting general practical principles from guidelines from the rural poultry farming, FAO, and CBBP justifies why CBIPDP is a well-placed project for Zambia’s indigenous poultry sector.
Conclusion
In conclusion, indigenous chickens are an integral component of agriculture in resource poor communities and has the potential to contribute to food and nutritional security, increased household incomes and access to livelihood assets for SSF in SSA, particularly towards the year 2050. To address concerns of the loss of IC-AnGR and the low socioeconomic gains reported among rural farmers in the indigenous poultry sector, CBIPDP is a workable research innovation strategy suitable for low-input agriculture production systems in Zambia. Designing the CBIPDP should be implemented in selected rural communities in Zambia based on lessons on the effectiveness of researcher-community-stakeholder engagements from other low-income countries. The CBIPDP would explore integrating resources and skills through researcher-community-stakeholders meetings when formulating strategies to mitigate challenges in the indigenous poultry sector. 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 indigenous poultry sector 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 acknowledge both the Australian and Zambian governments for supporting research in agriculture, environmental and rural science.

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I have read the revised paper and acknowledge that the authors have addressed some of my previous suggestions. The paper, however, still needs improvement before it can be indexed in an international scientific journal. First, the manuscript needs thorough editing for grammar, tense and punctual errors. These errors are just too many to mention one by one. I also suggest that, to ensure that ALL comments are addressed, the authors should include a response to reviewer letter that specifies how they addressed each of the comments below.

Although there is improvement, I am still concerned about flow of ideas in the manuscript. As I indicated my previous comments, all sentences in a single paragraph should be supporting the main idea of the paragraph. For example, page 5 second last paragraph, what is the main idea of the 'paragraph'? Page 7 Paragraph 1 under “Diseases and poor nutrition”, diseases and nutrition could be discussed in two different paragraphs. Without well-written paragraphs that flow logically from one idea to the next, the manuscript will be difficult to comprehend.

There is repetition in the document. For example, the section on “diseases and poor nutrition” briefly highlights nutritional challenges faced by the indigenous poultry sector in sub-Saharan Africa but there is also another section on “nutritional challenges”.

Paragraphs 2 and 4 on page 5 also have repeated information. There is more information which I think is repeated in the document, try to rectify this.

Page 3 paragraph 2 - Why are small stock important in the face of climate change? In this paragraph or the next one (I think these two paragraphs should be combined – see comment on paragraphing), authors should justify why the focus is on indigenous chickens.

Page 4 Paragraph 1 - “This paper highlights the role of indigenous poultry...”. Shouldn’t it be “indigenous chickens”? These terms are used interchangeably throughout the document. This
should be corrected. The same applies to the terms IC-AnGR and AnGR.

I think the section on “roles of agriculture and the value of indigenous chicken genetic resources in low-income countries” should be replaced by something like “The Sub-Saharan poultry industry” or “The Zambian poultry industry”. The section should mainly discuss the structure of the poultry industry including statistics, need be.

Page 5 Paragraph 1 - The statistics given here are just too old. Some over thirty years ago. Do they still hold value? Just like I emphasized in my previous comments, it is important that authors use young literature throughout the review.

Page 6 paragraph 2 - The topic is on chickens, but authors discuss guinea fowls in this section. Digression.

The section “Zambia’s poultry industry” can be merged with section on “roles of agriculture and the value of indigenous chickens…” and renamed “The Sub-Saharan poultry industry” or “The Zambian poultry industry”. See comment above.

More literature should be covered on the indigenous chicken breeds found in Zambia. Which breeds are common? Their performance? Are there pure breeds?...etc.

Page 9 - I suggest you include a subtopic on strategies to improve indigenous chicken production in Sub-Saharan Africa or Zambia. Maybe this can replace “research innovation and application”?

Is “increased consumer demand for indigenous chickens” a strategy to increase indigenous chicken production?

I am failing to understand how subtopics such as “increased consumer demand for indigenous chickens”, “population growth and food demand”, “food consumption patterns” fit under “research innovation and application”

Page 9 paragraph 4 - The statistics in the last sentence is outdated, from 21 years ago.

Page 9 paragraph 5 - what is the meaning of the phrase ‘period under review”? this should be corrected throughout the document. The sentence “...US$1 was equivalent...” should be deleted. In this paragraph, authors highlight an important point that there is a market gap for indigenous chickens. So how can this market gap be addressed? Are indigenous chickens producers aware of this gap? I think the creation of market linkages can be a very useful strategy in promoting sustainable productivity of indigenous chickens in SSA. Authors might want to comment on this

Page 10 - Maybe the subtopic “ Farmer mobilisation and sustainable interventions” can be changed to “intervention strategies for...”

Page 10 paragraph 1 - Authors highlight the issue of loss of IC-AnGR. IC-AnGR should be defined on first mentioning in text. This should be the case with all abbreviations and acronyms.

The loss of indigenous chicken breeds and strains is a big challenge in SSA. Authors should include more literature on this under the subtopic “Threats to the indigenous poultry sector in Sub-Saharan Africa”. Why are some of challenges highlighted here (continued loss of IC-AnGR, lack
of skills in animal management and absence of value addition) not discussed in detail under the subtopic “Threats to the indigenous poultry sector in Sub-Saharan Africa”?

Page 10 paragraph 2 - Authors tend to revert to discussing livestock and AnGR in general. They should focus on indigenous chickens. As I emphasized in my previous comments, authors should find a logical way to order and link their sentences, paragraphs and sections of the review. I would expect the review to start with a very brief broad background on livestock or just indigenous livestock, move on to poultry and then narrow towards indigenous chickens, not the other way round.

Page 10 paragraph 2:
- What exactly is involved in CBIPDP and CBBP?
- “Examples of community-based interventions”…should that be a subtopic?
- “Outcomes of CBBP” authors should avoid using acronyms in subtopics

Page 11 Paragraph 1 - For CBBP, authors gave examples for sheep and goats, are there any examples for chickens? Is the African chicken genetic gain program which covers countries such Zimbabwe and Kenya a good example? Authors should highlight what exactly is involved in these CBBP for chickens. The subtopic is on CBBP but authors go on to discuss vaccination programs under the same subtopic.

Chicken vaccination programs in SSA, including Zambia, should also be discussed. Check Dumas et al. (2017) and the Mawa project in Zambia.

Page 11 Paragraph 2 - The reference “Mueller” should be cited correctly.

Page 11 Paragraph 3 and 4 - See my comment on paragraphing above.

Page 11 Paragraph 6 and 7 - Contextualize.

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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.

Christopher Kanyama

The reviewers' report made important observations and offered helpful guidance. The following are our responses to concerns raised by the reviewer.

1. The paragraphs that had repetitions were either revised, summarized or merged. For example, the two paragraphs covered nutritional challenges and disease and poor nutrition. The same was done for some repeated information (deleted, or revised).

2. In the paragraph addressing small livestock on page 3 the paragraphs were combined and justification for promoting sustainable use of indigenous chickens was highlighted.

3. Page 4: The use of AnGR and IC-AnGR was rectified and consistently used throughout the article.

4. Section on the role of agriculture, we focused on The sub-Saharan poultry industry with some instances of figures from selected countries including Zambia.

5. Page 5: The old statistics revisited and replaced with more recent statistics/new literature, particularly on the proportion of indigenous chickens to the national flock, egg production per year and per capita egg consumption for selected countries in West, Southern and East Africa.

6. We changed the subtitle for the role of agriculture to the poultry industry in Sub-Saharan Africa's poultry industry

7. Page 6, paragraph 2: data on guinea fowls was revised as it was misplaced in the text.

8. The section on Zambia's Poultry industry was merged with roles of agriculture or SSA's poultry industry.

9. Common breeds are those highlighted in the paper. However, the literature on the performance of these Zambia indigenous chicken breeds is not adequately documented. Although the ministry booklets have some unpublished performance data. Should this be used?

10. Page 9: research innovation was replaced with opportunities and strategies to improve the indigenous chicken sector in SSA-This enabled us to cover the current status which translates into opportunities and strategies that included community-stakeholder engagements.
- Population growth, increased demand and consumption patterns were considered opportunities for small-scale farmers to sell their chickens and chicken products because the demand is likely to be driven by those factors.

- Outdated statistics were deleted.

- Term period under review and the exchange rate was deleted from the text. And the creation of market linkages was considered as one of the possibilities when mobilizing farmers through community stakeholder engagements.

- Farmer mobilization was included as a sub-heading under sustainable interventions.

- Searched for possible additional literature on the loss of indigenous chickens Animal genetic resources (IC-AnGR), -More common ones and details are from biodiversity status reports by FAO (2007/2015).

- The mention of other indigenous livestock was mainly useful in illustrating instances where Community-based interventions have worked in low-income countries and what challenges have been faced in those regions.

- Community-based programs are interventions that emanate from engagements between the researcher and the community. The main objective is to address a challenge related to indigenous livestock and breeding potential. So, solutions are created by researchers working together with farmers. The Community based indigenous poultry development program was a concept which would use some common principles found in CBBP such as working with small-scale farmers and focusing on Indigenous livestock breeds etc

Page 10: Acronyms were removed from most parts of the paper except the following: SSF, IC, IC-AnGR etc because of the number of these terms used in the paper.

11. Page 11: So community-based breeding program was taken as community-based interventions

- The approaches to interventions by Duma et al. (2017) was a very good example of a community-based intervention approach in that there is engagement between the researcher and the community when designing solutions. This was very helpful.

- Mueller was cited properly as Mueller et al. (2015). This concludes our responses to the queries raised by the reviewer. We hope that would help.

**Competing Interests:** None
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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