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Intervention options for small-scale family poultry development in south-eastern Madagascar: an expert survey

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Abstract

The diets of resource-poor farmers in the Atsimo Atsinanana (AA) region of south-eastern Madagascar have limited diversity and are low in animal protein. Although poultry farming is widespread, productivity is low, and consumption of eggs is uncommon. To enable effective development interventions targeting poultry value chains, this study pursues two goals: (i) to describe current challenges in small-scale poultry rearing and egg consumption in AA, and (ii) to explore viable options for promoting poultry production. We employ a survey approach, carrying out semi-structured interviews with 16 international and 12 local key informants (KIs) on small-scale poultry development. We find that poultry production in AA is critically constrained by high mortality due to diseases and predation, poor husbandry, and lack of veterinary services. The major health constraint is the Newcastle disease. Given the high mortality rates and low egg-laying potential of local chicken breeds, only small numbers of eggs are consumed, as farmers prioritise hatching. The main identified solutions include improvements in veterinary health and animal husbandry. KIs emphasised the development of animal health support services, including village vaccinators, upgrading feed with locally accessible protein sources, and the need for biosecure housing. Furthermore, training for farmers on poultry management, marketing, and vaccinations was suggested, in addition to creating awareness about the nutritional benefits of poultry products. Our findings are relevant to local development practitioners, as achieving food and nutrition security requires a multifaceted approach that fits local conditions. Our study provides actionable recommendations for improving small-scale family poultry production in AA.

Keywords: food security, development interventions, nutrition-sensitive agriculture, chicken, Atsimo-Atsinanana

1 Introduction

In Madagascar, agricultural productivity is predominantly low, and most rural people live below the poverty line (World Bank, 2020). Madagascar ranks 105th out of 107 on the 2020 Global Hunger Index, categorised as experiencing alarming levels of hunger (von Grebmer *et al*., 2021). Chronic malnutrition remains one of the biggest problems at the national level and especially in the south and southeast, where contrasting manifestations of malnutrition may be present at the same time. Food availability and food supplies are insufficiently diversified and inadequate in quantity to meet the nutritional requirements of rural populations. Anaemia, which can be caused by iron deficiency (but also by non-nutritional causes), affects 37 % of women in reproductive age (Farris *et al*., 2019). According to the FAO, IFAD, UNICEF, WFP and WHO (2022) in Madagascar for the timespan from 2019-21, nationally, 48.5 % of people were undernourished. In 2020, 6.4 % of children under the age of five years were wasted (acute malnutrition) and 40.2 % were stunted (chronic malnutrition). High levels of malnutrition are associated with significant micronutrient deficiencies, which can lead to lifelong physical or mental impairment (Farris *et al*., 2019; FAO, 2022). Agriculture is highly exposed to the impacts of climate change (World Bank, 2019). Changes in rainfall distribution, flooding, cyclones, and increasing intensity of drought events have led to reduced harvests (World Bank, 2017). Several consecutive years of drought, fuelled by climate change, have exacerbated the country's food insecurity, bringing parts of southern Mad-

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agascar to the brink of famine in 2022 (WFP, 2022). These challenges require a diverse set of solutions at various scales. At the farm level, small-scale family poultry (SSFP) production can potentially improve the productivity of smallholder farming systems and contribute to household food and nutrition security (Wong *et al*., 2017). Poultry production contributes protein and key micronutrients in bioavailable form to family diets and generates income (Farris *et al*., 2019). Globally, traditional poultry farming is typically managed by rural women and children who look after their animals as part of the daily household chores (Guèye, 2002; Iannotti *et al*., 2014; Mapiye *et al*., 2008). Poultry are kept for home consumption and for sale, often serving as an asset that can quickly generate income in case of urgent financial needs (FAO, 2008). In many places, poultry also plays an important role in social and religious ceremonies, such as births or weddings (Riise *et al*., 2005; Hamilton-West *et al*., 2012). In Madagascar, like in other parts of the Global South, SSFP is widely established, but faces challenges of low productivity, contributing relatively little to household incomes and diets. Strengthening poultry value chains through development interventions could improve the situation. However, there are many possible ways to stimulate poultry development and different, highly context-specific, approaches must be considered. To identify promising strategies for locally effective poultry development projects, we conducted an analysis of local challenges in a case study region based on key informant interviews. Our main research question was: What are viable development interventions for improving poultry rearing in the Atsimo Atsinanana (AA) region? By combining findings from qualitative international and local expert interviews (Key Informants), this study aimed to propose feasible intervention options for the development of poultry farming in AA.

2 Materials and methods

2.1 Study region

Atsimo Atsinanana (AA) lies on the south-eastern coast of Madagascar and is a sparsely populated region, with about 90 % of its population of around 825.000 people living in the countryside (IPC, 2021). In the AA region, recurrent acute food insecurity remains at alarming levels, with 52 % of households considered "stressed" (inability to afford essential non-food expenditures without engaging in stress-coping strategies) and 10 % in "crisis" (depleting essential livelihood assets to avoid acute malnutrition, or already facing acute malnutrition) in November/December 2021 (IPC, 2021). Food insecurity is the main cause of malnutrition, followed by a lack of sanitation and the need for better drinking water supplies due to recurrent droughts (Weiskopf *et al*., 2021).

2.2 Formative qualitative context analysis

Between November 2020 and March 2021, we conducted 16 focus group discussions (FGDs) with local farmers. The objective was to build an understanding of current SSFP systems in the study region. Eight all-women FGDs and eight all-men FGDs were held. We collected insights on the current situation of poultry production (e.g., numbers of chickens, health, housing, feed) and use of eggs and chickens, as well as farmers' views on current challenges regarding these topics. These results informed the local knowledge context for this study.

2.3 Preparatory literature analysis

We screened relevant literature, including both peer-reviewed and grey literature, gathering background information for the global picture on SSFP. This literature analysis fulfilled three purposes: first, it helped to identify relevant key informants (KIs) for subsequent interviews; second, it informed our questionnaire design; and third, we derived deductive codes for the later analysis of key informant interviews (KIIs). Recent, high-quality literature was identified online using the keywords shown in Fig. 1 and selected based on two criteria: year of publication (≥ 1990) and the number of citations (≥ 10). As most SSFP production systems raise chickens, we used the search terms "poultry" and "chickens" interchangeably. We used a combination of search terms led by different topics of interest. Examples of our explorative search terms include "small-scale poultry intervention options", "village poultry constraints" or "backyard poultry models".

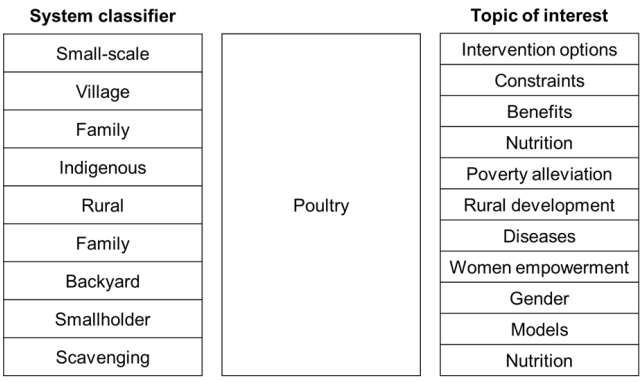

Fig. 1: *Search terms for preparatory literature review.*

Table 1: *Characteristics of international informant group.*

Interview	*Sector*	*Gender male/ female*	*Profession/ Area of expertise*	*Locations of expertise*	*Country of current affiliation*	*Mode of recruitment*
I1	Academic	m	Professor of Animal Breeding	SSA, specifically East Africa	Malawi	Author of relevant literature
I2	Practitioner	m	Livestock Specialist	South Asia	Sri Lanka	Snowballing
I3	Practitioner	m	Principal Agricultural Research Officer	Southern Africa	Botswana	Snowballing
I4	Academic	m	Researcher at the Institute of Agricultural Research	SSA	Niger	Author of relevant literature and snowballing
I5	Practitioner	m	Adviser for the Agriculture and Livestock	Bangladesh	Bangladesh	Author of relevant literature and snowballing
I6	Academic	m	Researcher in the Department of Animal Science and Production	SSA	Tanzania	Author of relevant literature
I7	Practitioner	m	Poultry Veterinary	SSA, South-eastern Asia	Indonesia	Snowballing and Author of relevant literature
I8	Academic	m	Researcher in the Department of Animal Science	SSA, Bangladesh	Bangladesh	Author of relevant literature
I9	Practitioner	m	Department of Animal Nutrition	SSA, Bangladesh	Bangladesh	Referral by GIZ
I10	Practitioner	f	Development Project Manager	Malawi	Malawi	Referral by GIZ
I11	Practitioner	m	Agricultural Development Advisor	SSA	France	Snowballing
I12	Academic	m	Poultry Expert; Poultry Institute	SSA	South Africa	Author of relevant literature
I13	Practitioner and Academic	m	Veterinary Doctor	SSA, Asia	India	Author of relevant literature
I14	Academic	m	Scientist in Livestock Genetics	Eastern Africa	Kenya	Author of relevant literature
I15	Practitioner	m	Project Manager	Global knowledge of SSFP	Burkina Faso	Snowballing
I16	Academic	f	Professor in Poultry Health	Global knowledge of SSFP	Australia	Author of relevant literature

2.4 Key Informant interviews

2.4.1 Sampling

We identified 40 international KIs (12 women and 28 men) from 24 countries according to their demonstrated expertise as authors of relevant literature, through referral by the staff of the German development agency '*Deutsche Gesellschaft für Internationale Zusammenarbeit*' (GIZ) in Madagascar, and through snowball referral. These inter-

Table 2: *Characteristics of local informant group.*

Interview	*Gender*	*Affiliate organisation*	*Sector*
L1	m	Catholic Relief Services (CRS)	Practitioner
L2	m	FAO	Academic and Practitioner
L3	m	Institut Malgache des Vaccins Veterinaires (IMVAVET)	Academic and Practitioner
L4	m	Agronomes & Vétérinaires Sans Frontières (AVSF)	Academic and Practitioner
L5	f	Farafangana; Ministry of Agriculture, Fisheries & Aquaculture, Livestock	Government Staff
L6	m	Antananarivo; Ministry of Agriculture, Fisheries & Aquaculture, Livestock	Government Staff
L7	m	Fonds Régional de Développement Agricole (FRDA)	Practitioner
L8	m	Pro-Resilience Action project (PRO-ACT), FAO	Academic and Practitioner
L9	m	Welthungerhilfe (WHH)	Practitioner
L10	f	GRET Madagascar	Practitioner
L11	m	Agrisud Madagascar	Academic and Practitioner
L12	m	LandO'Lakes	Academic and Practitioner

viewees were selected for being recognised experts in subtropical or tropical poultry science, animal science, and research for development, with expertise in the Global South. Interviewees had published peer-reviewed papers on small-scale poultry systems or had extensive practical experience in development projects with poultry components. A total of 16 KIs from 14 countries were interviewed (see Table 1). Our sampling was determined by availability and is not exhaustive of potentially knowledgeable informants. To get specific local advice for intervention options in AA, 21 local KIs (6 women and 15 men) were contacted. They were either Malagasy citizens or (previously) working in Madagascar in development projects with a poultry component. Like the international interviewees, many local key informants were also recognised scholars in agriculture or livestock, poultry science, animal science, and research for development with a track record of relevant publications. In addition, we also contacted practitioners with experience in poultry interventions in Madagascar (preferably in AA) and/or knowledge of the regional context. Multiple local KIs were contacted after referral by an international informant. Local KIs included members of international NGOs, local NGOs, governmental bodies, and charitable foundations. A total of 12 local KIs were interviewed; all interviewees held university degrees, with the majority holding a Ph.D. Their characteristics can be found in Table 2.

2.4.2 Interview execution

We carried out 28 semi-structured KIIs to collect existing knowledge about SSFP production, to understand existing constraints, opportunities, and intervention options for SSFP production, and to gain knowledge about the local context. However, it is not always a straightforward matter to identify what applies to SSFP in general and what applies specifically to AA/Madagascar. We sought to find patterns in the experiences and advice shared by international and local KIs to assess constraints, opportunities, and viable development interventions suitable for SSFP. We did not exclude any kind of interventions, with the goal of examining through deductive and inductive coding which interventions were deemed most suitable. A semi-structured interview method was chosen to get a sufficient and complete picture of the possible intervention options. Interview guides were created based on the main topics identified through literature analysis. During the data collection period (November 2020 – March 2021), the interview guides were partly adapted to account for new information. For example, the original focus on chickens was widened to include all poultry species, which was emphasised by some of the KIs. All interviews were conducted via video telephony by the first author and all but three were held in English. Three local KIIs were joined by a French interpreter. The interviews averaged 31 minutes. All interviews were video- and/or voice-recorded using either the Zoom or

Skype software with the permission of the Interviewees and transcribed using the software Otter.ai (https://otter.ai/).

2.4.3 Interview analysis

All interviews were transcribed verbatim; subsequently transcripts were subjected to structured and summarising content analysis (Mayring, 2015). Coding and data analysis were carried out with the MAXQDA software (VERBI Software, 2021). In a first step, international KII transcripts were analysed using deductive categories and codes based on the literature analysis. This was conducted with the assumption that international KIIs would be similar to international literature. In line with our research interest, the coding categories were divided into 'constraints' and 'interventions'. In a second step, aimed at gaining as much new knowledge as possible about the local context, we analysed the local KIIs through inductive category formation. Here, new categories were created during the coding process to narrow down the text elements without distorting the core content and essence of the material. This reduction is intended to create clarity of the data that still corresponds to the basic form of the material (Mayring *et al*., 2010). However, to enable the synthesis of international and local knowledge, we maintained the deductive main categories. Section 3 presents the main constraints and intervention options pointed out by the informants. The order of its subsections follows the frequency of the coded segments, i.e., how often they were mentioned in the interviews. Individual interviewees are abbreviated as I# and L#, where I and L represent international and local KIs and # is replaced by an individual number.

3 Results

3.1 Background knowledge on the local poultry production context

Most poultry in the study area are local chickens, "*poulet gasy*", with occasional ducks and geese. Ducks and chickens are usually kept together. An average household has about five chickens. Women are the primary caretakers of the poultry, as they typically stay at home; however, sometimes men and children may also be involved. In Farafangana, men sometimes use roosters for cockfighting.

Poultry are generally housed in the space below the owner's stilt houses. No special feeding or housing techniques are practised, but some owners check the number and health of the animals in the evening. To prevent diseases sick birds are regularly provided with water and were said to be treated with a combination of traditional medicines, such as water and pepper, vinegar and sugar, ground coffee, and a mixture of oil and tobacco. If a chicken is unable to fight the disease, it is usually slaughtered and eaten.

The focus group participants indicated that the main reasons for raising poultry were to sell them in emergencies or save money (school fees, illness) and use them for home consumption. Chickens are often sold to buy staple food during the two hunger periods (February to April, and September to November).

Regarding willingness to participate in training and development interventions, participants were particularly interested in poultry health interventions such as vaccination, although they felt that these were not always effective. When asked if they would be willing to have their chickens medically treated, the majority answered yes, because diseases are a significant problem and chickens could be a good source of income. They would also be willing to learn on housing, feeding, and other management practices.

3.2 Constraints

3.2.1 Diseases and inadequate access to veterinary services

Like in many rural settings of SSA, the main constraint affecting SSFP in AA is the disease pressure contributing to high mortality and low productivity. The main disease constraints in AA are identified as Newcastle disease (ND, caused by the Newcastle disease virus) and fowl cholera (caused by the bacterium Pasteurella multocida). Fig. 2 and 3 highlight the importance of disease constraints, as specified by a local informant: "(...) *the two main diseases are ND and fowl cholera. For the avian flu, it's not yet present everywhere so there's a lot of regions which are still not touched by it*." (L12).

ND occurs all year round. In practice, ND and fowl cholera appear to have similar symptoms to farmers in the region, who tend to give them the same names ("*barika*" or "*beaty*"). Like in most parts of the world, avian influenza, fowl pox, and coccidiosis are common illnesses that afflict poultry in AA. The symptoms of ND resemble those of highly virulent avian influenza. The prevalence of these illnesses varies throughout the year in AA, with the most prominent peaks occurring during both the coldest (June-July) and the hottest (August–September, November–December) months. Disease infestation is facilitated by contact with other poultry from neighbouring farms, as chickens roam freely, and flocks intermingle. Furthermore, as in other SSFP systems, chickens in AA are susceptible to illness and mortality due to poor housing, hygiene, and inadequate feeding. In addition to infectious diseases, chickens frequently die by predators or from being hit by cars.

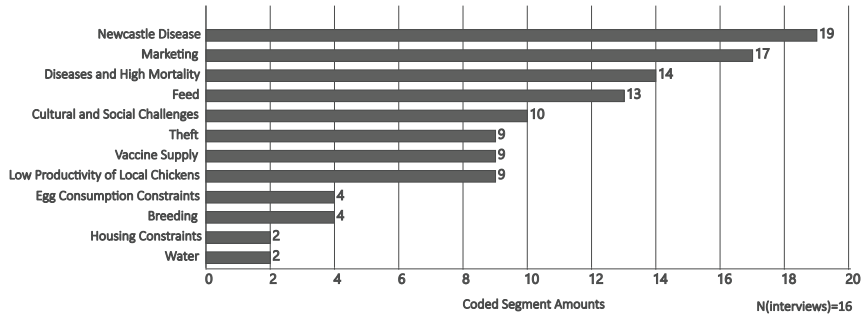

Fig. 2: *Overview of poultry production constraints based on coding of international key informant interviews.*

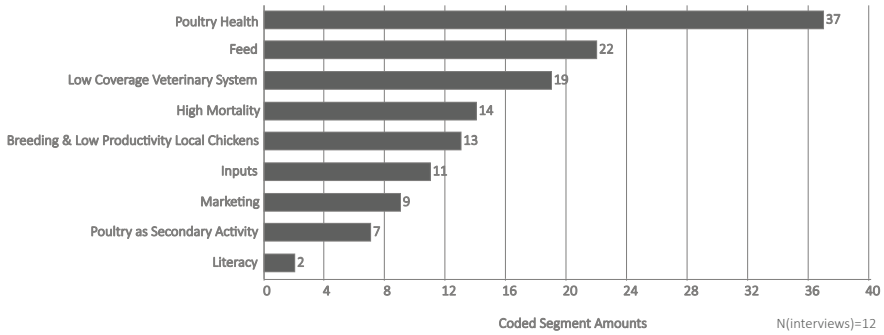

Fig. 3: *Overview of poultry production constraints based on coding of local key informant interviews.*

Most diseases, including ND, can be vaccinated for, but many vaccines require a reliable cold chain to maintain effectiveness. Maintaining a consistent cold chain is often challenging in rural areas because electricity is needed for refrigeration. In addition, the packs of some commercially available vaccines contain a large number of doses, so they are considered unprofitable under village conditions, as "*some vaccines come packaged into 500–1000 doses or more*" (I14). Local informants reported that the veterinary system does not meet SSFP farmers' needs due to the uneven distribution of veterinarians across the country and the inaccessibility of animal health services in remote areas. Medical inputs are costly due to insufficient development of local distribution networks, high transportation costs, and high vaccine costs (500-600 Ariary/chicken, about USD 0.12–0.15). As poultry farming is considered by farmers to be a secondary livelihood activity, investments into animal health are rare.

3.2.2 Limited access to quality feed

Access to quality feed is another challenge, as the quantity and quality of the feed base is a key factor influencing chicken growth and reproduction. Buying commercial feed, however, is considered too costly by many farmers, as I1 notes, "*each region you need to find an appropriate source because buying feed is not an option*". Letting poultry roam freely is common in SSFP production in AA, but foraged feed is limited in both quality and quantity. Protein sources are especially limited, yet during the chick stage, limited feed means limited growth: "*The main constraint is that all the animals are dying [of starvation], especially the chickens. This is due to the fact that they require additional feed*" (I10). In AA, where feed sources are scarce, competition can occur between animal feed and human food, as virtually anything edible is consumed by people during the lean season. This includes rice husks, rice grains, and cassava peel.

3.2.3 Low productivity of local chicken breeds

The chicken populations of local breeds (poulet gasy) are characterised by low egg-laying performance compared to exotic breeds. Laying cycles are less frequent, with a maximum of 60–75 eggs per year, while commercial breeds can lay up to 130–150 eggs per year. In addition to lower egg-laying performance, local chicken breeds grow more slowly than improved or exotic breeds. Although the weight gain and egg-laying potential of local chicken breeds are already low, productivity is further limited by minimal disease control and inadequate feed. Nevertheless, farmers in AA tend to prefer local breeds. Local chickens are smaller, more effective at escaping predators, and have better scavenging

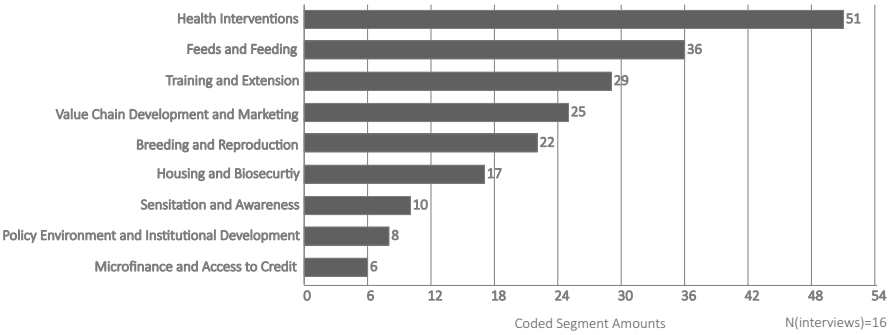

Fig. 4: *Overview of interventions mentioned in international key informant interviews.*

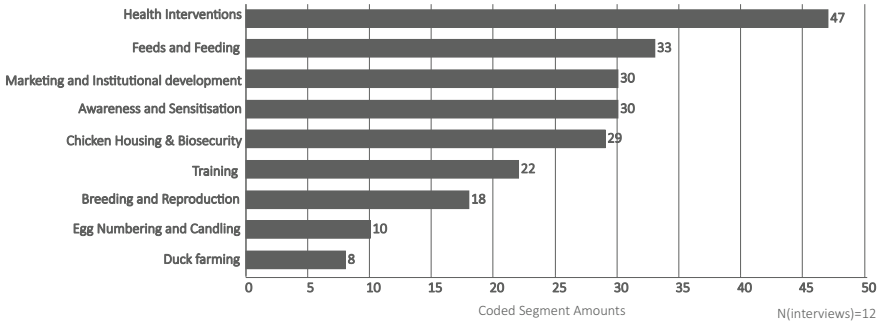

Fig. 5: *Overview of interventions mentioned in local key informant interviews.*

abilities. Exotic breeds require more feed, which would often exceed the investment capacity of the rural population.

3.3 Interventions

3.3.1 Poultry health interventions

In line with the importance of diseases as a constraint, health interventions were strongly emphasised by both local and international informants (see Fig. 4 and 5). Effective ND control is widely considered a prerequisite for thriving SSFP. According to a local informant, if the health status is sustainably improved, the number of surviving chickens may double, especially in places where mortality rates are high. To reduce mortality and improve the productive performance of animals, interviewees highlighted the importance of developing rural poultry health services, including for prevention and treatment of disease. Therefore, health interventions were considered to have the highest priority for interventions in SSFP by all informants.

To overcome the insufficient coverage by veterinarians, farmers can be trained to become village vaccinators in AA. It was emphasised that training local vaccination agents and mobilising them for annual or monthly vaccination campaigns against fowl cholera and ND should be a priority for the local context. In principle, vaccines are available, as indicated by local informant L12: "*Fortunately, there are already effective vaccines that can be used [in Madagascar]*". Since 2015, a thermotolerant ND vaccine was developed and has been made available to certain areas in Madagascar, possibly overcoming the challenge of maintaining cold chains. However, despite the availability, the demand for ND vaccination is low due to the low willingness to invest money into poultry farming. Vaccination campaigns should ideally be held shortly before the peak-season of ND, but generally 3–4 times per year, to ensure that the flock is protected during the year. In addition, however, local KIs underlined that vaccinations should be accompanied by changes in other management practices. For example, local informants said to prevent cross-infection between different animals should be kept or housed separately. However, in an extensive system, where scavenging is often the major source of food, birds must be allowed to roam freely during the day but can be kept inside at night.

3.3.2 Interventions on feeding

The use of supplemental feed can boost SSFP production and help the flock thrive at times when the scavengeable resource base is insufficient in rural contexts. To keep costs low, locally available feed ingredients that do not com-

Table 3: *Proposed feed options.*

Protein	*Energy*	*Mineral supplements*
Small insects	Sorghum	Seashells
Peanuts/ sub-products	Amaranthus grain	Bones
Moringa oleifera	Kitchen scraps/ Leftovers	Eggshells
Fish waste	Cassava (ground)	Molluscs
Earthworms	Maize and groundnut (ground)	
Termites	Rice/ Maize/ Wheat bran	
Locusts	Water from cooking with food particles	
Maggots	Millet	
Blood meal		

pete with human nutrition should be promoted, especially by-products of agriculture and domestic food preparation. Table 3 shows feed alternatives available in the study region, as suggested by local informants. "*For feed, I would suggest the promotion of cassava cultivation in basket compost and awareness raising for maize and groundnut cultivation... Fish waste can also be recovered for coastal areas*" (L8). Where farmers have little resources, supplemental feed may be offered only to certain animals or age groups, such as young chicks, layers, or broody hens. In locations with more rainfall, the feed supply is often greater and there is a larger variety of household-sourced feeds, such as cassava and horticultural waste.

3.3.3 Value chain development and marketing

The use of a value chain approach was mentioned by 19 of the 28 KIs. It was emphasised that all parts of the value chain, from access to inputs to marketing of outputs, need to be considered to address relevant constraints through a holistic approach that involves diverse stakeholders. Limited market access is a particularly strong constraint for SSFP development in AA. To better address local market demand in the study, one KI pointed out that consumer habits in each region should be assessed and product analysis should be conducted. Farmer associations and cooperatives are generally recommended as solutions for the limited market access of individual farmers through the provision of information, infrastructure, and logistical assistance. Cooperatives could benefit from economies of scale in marketing their outputs to large-scale buyers and traders. For the study region, this model may be validated by establishing a showcase site with poultry rearing cooperatives in several municipalities. Local KIs pointed out that the seasonal formation of farmer groups and short-term associations of (women) farmers can be useful tools to reduce input and service overheads, e.g., during harvest time when demand in the market is high for poultry products.

3.3.4 Training and extension

Training and extension refer to the creation of knowledge and technical skills among poultry farmers. This was stressed by international KIs as being important for the long-term sustainability of SSFP production. Trainings in AA should cover topics around the use of local feed, housing, breeding, health, and biosecurity, for example. Additionally, trainings can support the development of business plans for establishing farmer cooperatives to promote marketing and value chain development for locally produced products. Trainings in AA should be conducted in the local language (Malagasy) and training materials must be appropriate to local literacy levels. Community-based education using a holistic approach should be the focus for all SSFP systems. Other tools mentioned for the study region include Farmer Field Schools (FFS), radio announcements, and WhatsApp groups. "*We are doing an FFS approach. We teach them a technical package in the FFS like how to improve health, like vaccination and prophylaxis, and improvement of feed, complimentary contribution, improvement of habitat, and the improvement in breeding.*" (L4) Establishing model farms close to the villages and professional assistance throughout provided trainings were additionally recommended for the local context. Local KIs emphasised that farm visits with an exchange of experiences between farmers during training can facilitate knowledge sharing as well as have an impact on awareness raising. For SSFP poultry-oriented interventions integrate well with kitchen and community gardens, as well as home gardening were recommended.

3.3.5 Biosecure housing

International informants and literature sources highlighted that housing chickens in closed coops, rather than letting them nest outside, can reduce the risks of losses due to harsh environmental conditions (such as intense radiation), theft, predators, and diseases. Separation of chicks and hens, as well as separation from other chicken flocks and

other poultry species, are important ways to minimise disease pressures. Hen houses or clean baskets in secure locations are useful to protect chicks and brooding hens. Housing birds also makes it easier to inspect for symptoms of disease or injury and to vaccinate. Local KIs recommended training farmers in AA in methods to provide animals safe, biosecure housing. This includes fencing chicken houses to prevent infection from other flocks, preventing human visitors from entering the henhouses, and regularly cleaning chicken houses.

Raw material for building chicken coops is available in the study region, but farmers may need to be provided additional hardware, such as grids, nails, hinges, or padlocks, to be able to construct adequate henhouses. To disseminate good practices on housing, it was suggested to establish demonstration sites adapted to local conditions. When constructing poultry houses, a special focus for the study region should be put on adequate orientation in terms of wind direction, number of shelters for brooding hens and chicks, avoidance of potential fire sources, and shade. Closer to the coast, strong winds are more frequent, temperatures are higher, solar radiation is stronger, and rainfall events are more frequent than in the highlands. Thus, in coastal areas of AA, the henhouse should be built to withstand intense rain, should provide sufficient shade, and be built far from sources of fires.

3.3.6 Breeding and reproduction

To improve the reproductive performance, crossbreeding local chickens with exotic breeds is not an option for AA, as the Madagascar Ministry of Agriculture, Livestock, and Fisheries discourages crossbreeding interventions. This is said to be due to the unique meat taste, texture, and usage for local dishes of the local chicken breeds. Another solution pointed out by local KIs was to improve genetic quality by phenotypic characterisation, in combination with good management practices. They referred to breeding the healthiest males and females to increase the productivity of local chickens over time.

3.3.7 Sensitisation for nutrition benefits

In addition to production-oriented extension and advisory, international KIs emphasised the need for raising awareness about the use of eggs in family diets. Because poultry production is typically oriented toward the sale of live animals, eggs are mainly used for hatching chicks. Therefore, farmers generally consume few eggs. "*So, people are mostly multiplying their chickens and in hard times they will sell them. So, they are not exactly consuming it themselves there must be sensibilisation campaign or awareness campaign on the benefits of eating the eggs or integrating it into the local diet*" (L5). Active promotion of egg consumption could change perceptions toward egg consumption. Such campaigns can add to technical interventions leading to higher chick survival rates, increased flock sizes, and improved animal health. These interventions are needed for egg production to exceed the needs for brooding and generate a surplus for home consumption. An important point to emphasise during awareness and sensitisation campaigns is the nutritional needs of infants and pregnant or breastfeeding women, which can be integrated into agronomic trainings.

3.3.8 Identification of unfertilised eggs

As most farmers in AA are primarily interested in hatching eggs for selling mature chickens, unfertilised eggs can be consumed as a priority. Farmers can visually determine whether an egg has been fertilised and contains a living embryo by using a candle or a flame. During periods of lower temperatures, the sale and consumption of eggs should be particularly encouraged, as hens usually cannot hatch more than eight eggs per cycle in cooler weather. According to the observation of KI L12 during their project implementation they noticed that within each laying cycle, the first few eggs are typically unfertilised under village conditions. Thus, farmers could consume the first eggs laid. Every day, when eggs were laid, they were marked with the current date (e.g., laying date serial number) to identify which eggs did not hatch. Informant L12 explained the project like this: "*What they actually did is a technique of numbering the eggs... one hen lays eggs for 21 days, like three weeks. The eggs from the first three days almost never hatch... they are not fertilised... So, they did an awareness campaign to inform the farmers that those eggs can be consumed, as there won't be a chick produced out of them*".

4 Discussion

4.1 Health

Disease pressure from ND has been identified as the greatest challenge to current SSFP practices in the AA. High ND mortality rates of up to 100 % affect SSFP in many locations worldwide (Maho *et al*., 2004; Ahlers *et al*., 2009; Ashraf & Shah, 2014; Osti *et al*., 2017,). In the study region, this health situation is exacerbated by the low availability of veterinary services combined with relatively high costs of vaccination. Outbreaks worldwide are associated with a variety of factors, including lack of biosecurity, inadequate vaccination and vaccination programmes, antigenic variation, maternal antibody inhibition of live vaccines, short duration of the immune response and immunological suppression (Dimitrov *et al*., 2017). Disease outbreaks in AA

are seasonal and depend on weather conditions (occurring in the warmer seasons), like in Chad, Mozambique and Nepal (Maho *et al*., 2004; Harrison & Alders, 2010; Osti *et al*., 2017). According to Dinka *et al*. (2010), ND is most prevalent in Ethiopia during the rainy season (June to August). On the other hand, Cappelle *et al*. (2015) claim that their findings in Mali confirm the seasonality of ND found in African backyard poultry, with epidemic peaks occurring mainly during the dry season. Maho *et al*. (2004) explain that in the Republic of Chad, an increase in ND cases is due to increased trade during the holiday season. In the study by Osti *et al*. (2017), Nepalese farmers argued that disease outbreaks could be caused by vendors using the same transport vehicles for feed and eggs when travelling from farm to farm. They also indicated that veterinarians could be another source of disease transmission from one farm to another. Since veterinarians and their services are scarce, the latter reason seems less likely in AA.

Significant growth in the size of flocks and the profitability of poultry have been achieved through effective ND vaccination programs (Harun *et al*., 2009, Mgomezulu *et al*., 2009, Harrison & Alders, 2010). Besides charging farmers a small fee, engaging women as community vaccinators can be a critical success factor for the sustainability of vaccination programs (Alders *et al*., 2010; FAO *et al*., 2012). Training community vaccinators is shown to be an effective approach for addressing animal health issues at the village level but is yet to be used throughout Madagascar (Alders, 2003; Alders *et al*., 2010; Campbell *et al*., 2018). In remote locations, where cold chain facilities are not accessible, the use of thermotolerant ND vaccination is advised for chicken production (Copland & Alders, 2005; Campbell *et al*., 2018; Annapragada *et al*., 2019). Currently, expenditures on poultry health are not common by households in the region. Thus, financial support to pay for vaccines may need to be provided initially. If vaccinations prove to be beneficial and profitable, even the poorest farmers may be willing to pay for vaccines (Maho *et al*., 2004; Campbell *et al*., 2018). Proper timing of vaccination campaigns, as well as coverage (60–80 % of the poultry population), and biosecurity should be taken into consideration during the planning process (Alders *et al*., 2003; Ashraf & Shah, 2014, Campbell *et al*., 2018).

4.2 Feed

Insufficient and low quality feed is identified as one of the main obstacles limiting SSFP globally (Mapiye *et al*., 2008). Scavenging typically supplies about 60-70 % of a bird's nutrient requirements (Alders & Pym, 2009) and upgrading the scavenging feed-resource base with supplemental feeding is documented as a promising intervention (Jensen & Dolberg, 2003). Commercial feeds, based on human-edible grains, have good nutritional values, but they are prohibitively expensive and their appropriateness for local poultry is unclear (Kingori *et al*., 2003). Rather, there are locally accessible alternatives that are not consumed by the farmers themselves or are seasonal (Alders & Pym, 2009). For protein feed in inland regions of AA, rearing of earthworms and maggots (on cattle blood or dung) was suggested by the local KIs. Experiences from other countries underline the potential of this practice (Fotsa *et al*., 2007; Khan, 2018). International KIs also suggested exploring Moringa oleifera as it is widely distributed in Madagascar and could potentially function as an alternative for antibiotics (Mahfuz & Piao, 2019). However, using it as a feed supplement remains controversial, as its positive effects appear to be contingent on preparation, dosage, duration of feed supplementation, and other details (Khan *et al*., 2021). Sufficient water is likewise important to optimise poultry production. Its supply remains a challenge in terms of quality and quantity. Water availability for chickens in AA is sporadic, as it is in most free-range poultry systems globally (Ahlers *et al*., 2009).

4.3 Housing and biosecurity

The adoption of improved chicken housing remains low in most tropical countries (Nahamya *et al*., 2006). Unhoused chickens, however, are susceptible to rain, cold, predators, and theft, as well as posing management challenges in screening for symptoms of illness or injury and immunisation against diseases (Guèye, 2002; Ahlers *et al*., 2009). Predators, diseases, and theft account for 100 % of flock losses in Ethiopian free range production systems: all three of these risks can be reduced with proper housing (Mekonnen, 2007). Improving biosecurity can be considered one of the most effective measures for disease prevention, as disease transmission to the farm can occur through humans, wild birds, the air, and transportation routes (Ssematimba *et al*., 2012). Biosecurity can be improved, for example, by (partially) covering the outdoor enclosure with nets, disinfecting hands before and after handling the chickens, minimising the number of people who have access to the chickens, and especially prohibiting visitors from entering the chicken enclosure. Local KIs mentioned housing interventions (29 coded segments) more often than international KIs (16x). Complete confinement is only advised in situations where good access to key productive resources, such as balanced feed or day-old chicks is guaranteed. When fully confining the chickens, trade-offs between decreased contamination, increased labour burden, and restricted scavenging must be considered.

4.4 Training

According to Guèye (2005), specialised extension for family poultry is only effective if combined with other interventions, like research, input provision, credit, as well as marketing support for poultry and its products. SSFP farmers may learn from interacting with their neighbours (Guèye, 2003, 2005). Based on the concepts of Farmer Field School (FFS), experiences from Vietnam and Kenya illustrate how to establish interactive training approaches for extension professionals and farmers (Khisa & Ondwasy, 2004; Riise *et al*., 2004). Organising farmers into groups to facilitate training and mentoring by selecting an exemplary, leading, or motivated farmer was recommended by several local and international KIs in our study. Studies from Benin and Senegal show that the average flock size increased more than 50 % after one year of interventions (Frederiksen, 2004; Chrysostome *et al*., 2002). Because extension services share information and build knowledge and skills, regular extension visits can help sustain the adoption of improved poultry management measures (Ochieng *et al*., 2012).

4.5 Marketing

Weak market access and the resulting low bargaining power are important challenges for poultry farmers in the rural areas of AA, especially in coastal areas. Information asymmetry, climatic hazards, and the exercise of market power further contribute to low sale prices generated by farmers (FAO, 2014). Cooperatives and farmer associations can help to address these problems (Rahman, 2011). Better access to a market with a short marketing chain between producers and consumers yields higher prices for the products and higher returns for the farmers (Aklilu *et al*., 2007). Successful marketing is especially important when farmers must sell poultry and products quickly because of urgent cash needs (Riise *et al*., 2005). To mitigate fluctuations in market prices for live chickens, setting up an information system, such as eSoko (Etwire *et al*., 2017), and supporting farmer groups to increase the value of their products could be considered. A combination of village poultry development programs with microcredit or microfinance programs has been successfully used in Bangladesh (Jensen & Dolberg, 2003).

4.6 Breeding and reproduction

In several African countries, genetic improvement through crossbreeding is used to improve or remove specific qualities in chickens (Phillipson *et al*., 2011). However, the results are not consistently positive. For example, in Zimbabwe, results show that crossbred chickens are relatively vulnerable to disease, predators, and periodic feed scarcity (Mapiye, 2008). Additionally, the opposition to crossbreeding by the Ministry of Agriculture, Animal Husbandry, and Fisheries in Madagascar, deems crossbreeding unsuitable for the Malagasy context. Similar restrictions exist in many low- and middle-income countries to protect local chicken breeds (e.g., Ethiopia; Fulla, 2022). Improving genetic quality by phenotypic characterisation, is quite different from the reality for most SSFP production systems, where many chickens roam freely and reproduce autonomously, without a strategy based on genetic potential.

4.7 Value chain approach

The strongest effects are likely to be achieved by combining multiple of these interventions through a holistic and integrated approach that looks at the entire production system and value chain. By taking a holistic approach to SSFP development, which considers both technical and organisational aspects, it is possible to develop poultry production systems based on locally available resources that may help poorer farmers to develop their skills and to create a sustainable income as well as ensure products for home consumption (Alder *et al*., 2018; Riise *et al*. 2005). A holistic, long-term development approach should identify locally appropriate strategies for scaling up successful practices, which may include model farms, demonstration sites, extension services and field schools for farmers, among other approaches.

5 Conclusion

With current low productivity and high mortality, there is ample scope to increase the contribution of family poultry to farmers' livelihoods and diets in the Atsimo Atsinanana region of Madagascar. Public and private development organisations may generate strong impacts with interventions targeting animal husbandry and poultry health. In particular, investments in vaccinations against Newcastle disease with sustainable community-based vaccination programs, quality housing using local materials, and supplemental feeding can help rural communities build resilient, productive, and sustainable family poultry systems. However, to ensure that increased productivity translates into greater consumption of poultry products significant awareness raising regarding the nutritional benefits of eggs may be needed.

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Conflict of interest

The authors declare that they have no conflict of interest.

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