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Livestock Development Institute

POULTRY BREEDING PROGRAM: THE CASE OF INDIGENOUS HORRO CHICKEN BREED

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The LFSDP's support in preparing and printing these policy documents establishes a definitive "genetic roadmap" for Ethiopia's livestock and fisheries transformation. These formalized strategies act as vital safeguards against disorganized breeding, preventing inbreeding, the erosion of indigenous traits, and the inefficient use of resources. Without such frameworks, a nation is essentially driving in the dark; these manuals provide the "headlights" and "GPS" required to reach a productive, climate-resilient destination. By institutionalizing these guidelines, the Ministry ensures livestock resources are managed with scientific precision and sustainable foresight. Ultimately, these documents bridge the gap between traditional smallholders and a modern, commercialized industry, guaranteeing inclusive and enduring growth.

Foreword

Demand for livestock and livestock products is increasing globally and in Ethiopia specifically due to population growth, urbanization and increase income. To fill the growing gap between demand and production, Government and private sector investment in animal feed and feeding, genetic improvement and animal health are recommended in the Ethiopian Livestock Master plan. Besides, sector specific policies, strategies and programs are keys for a sustainable livestock sector development. The current livestock production and productivity in Ethiopia is very low mainly attributed to availability of livestock feeds and genetic potential of the indigenous breeds/types. Ethiopia being a country with huge livestock genetic diversity and the availability of high between and within breed variation in economically important traits is an opportunity to utilize the genetic resources with appropriate feeding and health care for the benefit of the society. To ensure proper utilization, conservation and improvement of Livestock genetic resources, the National Animal Genetics Improvement Institute (NAGII) in the MoA, has developed livestock breeding policy and strategies for five livestock commodities (dairy cattle, beef cattle, poultry, small ruminant, and camel breeding strategies). Translating the policy and strategies into action requires development of breeding program.

On behalf of the Ministry of Agriculture, and the National Animal Genetics Improvement Institute (NAGII), I would like to extend my appreciation to Dr. Zemelak Sahle Goraga, EIAR), Ato Yonatan Zewudie (MoA) who were actively involved in the process of developing this national breeding program (national poultry breeding program: the case of indigenous horro chicken breed)

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Abbreviations

AFE	Age at First Egg
CSA	Central Statistical Authority
CSR	Chick Survival Rate
DZARC	Debre-Zeit Agricultural Research Center
DOCs	Day Old Chicks
EIAR	Ethiopian Institute of Agricultural Research
EBI	Ethiopian Biodiversity Institute
GTP	Growth and Transformation Plan
HTC	Hatchability
IFP	Improved Family Poultry
ILRI	International Livestock Research Institute
LMP	Livestock Master Plan
MoA	Ministry of Agriculture
NAGII	National Animal genetic improvement institute
RARI	Regional Agricultural Research Institute
TFP	Traditional Family Poultry

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EXCUTIVE SUMMARY

This breeding program is prepared for sustainable genetic improvement, dissemination and maintenance of Horro chicken breed targeting semi-intensive and extensive systems in its niche area in the country. As the horro farmers are more interested to have improved dual purpose chicken breed, this horro chicken breeding program is designed towards developing improved dual purpose breed that can best fit in horro environment and produce comparatively much higher (three to five folds) products (eggs and meat) as compared with the performance of unimproved indigenous flocks. A 3-tier closed nucleus breeding program was selected as the best scheme for dual-purpose horro chicken breed development, multiplication, dissemination and maintenance. Based on traits' economic value analysis and prediction of their genetic responses, the selected breeding goal traits are number of eggs, body weight, age at first egg, egg weight and survivability. So, a multi-trait index selection approach is suggested to select genetically superior individuals to be used as parent of next generation.

In the selected 3-tier closed nucleus scheme, genetic gain is generated in tier-1 which is at Debre-Zeit Agricultural Research Center (DZARC) and transferred in form of fertile eggs to tier-2 which represents Regional Multiplication and Rearing Centers (RMRCS) e.g. Bako RC and Ambo RC at Ginchi sub-center, for multiplication, rearing and dissemination. Afterwards, 3 months old chicks will be transferred from tier-2 to organized breeder groups (model farmers) representing tier-3. A job creation intervention will also be made for jobless youth groups to raise day old chicks and sale them at age of three months old. So, the breeder farmer groups will sale their fertile eggs to organized youth groups. Those youth groups will be organized as commercial producers (chicken producing micro-enterprise) to raise day old chicks and sale them in the local markets at the age of three months. The youth groups will be linked to the RMRCs to get access for hatchery facilities so that they can hatch their fertile eggs at RMRCs. The remaining smallholder farmers who are not part of the organized breeder groups, will receive genetic materials of horro chicken in form of improved cocks, three months old chicks, or fertile eggs from different sources such as from breeder groups (fertile eggs), RMRCs (three months old chicks) and from commercial producers or micro-enterprises (three months old chicks). So, every year, some new

breeder groups will be organized and each group will have twenty five members. The new member of a breeder group will be provided with twenty five young grower horro chicken (twenty female & five male). Afterwards, all the surplus breeding cocks from nucleus and sub-nucleus will be disseminated to smallholder farmers in base population. Once those smallholder farmers receive improved breeding cocks, they will cull their unimproved cocks of indigenous horro for slaughtering.

The breeding program will support the government to achieve its development goal on transforming traditional chicken farms into improved family poultry units. So, it will be possible to transform the traditional horro chicken producing smallholders' farms into improved family poultry units where improved horro with associated package can be provided for organized farmers and other community groups with the ultimate goal of improving family livelihood through increasing household nutrition, income, job creation and asset creation. As this breeding program will be implemented following a within horro breed selection approach, it will be in favor of conserving the base population, i.e., the risk of contaminating the gene pool of the base horro population is null. Furthermore, the breeding program is prepared in such a way that it can be applied (with little modifications) to genetically improve, disseminate and maintain other indigenous chicken breeds or ecotypes in Ethiopia.

1. INTRODUCTION

Poultry production is one of the most important livestock sub-sector which is practiced by several millions of urban, peri-urban and rural households in Ethiopia. The poultry sector plays vital role in insuring food security, income generation, export promotion, import substitution and strengthening the country's economy and the livelihoods of smallholder farmers. Keeping poultry, particularly domestic chickens is the backbone economy base of poor resource households particularly for rural women. Poultry production also has social, cultural and religious importance, and plays a significant role in family nutrition and poverty reduction.

In Ethiopia, there are a total of 59.4 million chickens, of which 85.7%, 7 % and 7.3 % represents indigenous, hybrid and exotic chickens, respectively (CSA, 2018/19). Village chicken represents the majority of the chicken population of the country and they are mainly kept under traditional family poultry production system which is characterized by high disease and parasite infestation, predation, harsh climatic conditions, unavailability and less quality feeds, and uncontrolled breeding (Jansen et al., 2009; Msoffe et al., 2009; Sekeroglu and Aksimsek, 2009; Kumaresan et al., 2008; Gondwe and Wollny, 2007).

The production and productivity of indigenous chicken is very low as compared with cross-breeds and exotic ones. This is not only due to the failure to use inputs but also due to the flocks' poor genetic potentials. The mean annual egg production of indigenous chickens is estimated at 40-60 small eggs with thick shells and a deep yellow yolk color (Alemu and Tadelle, 1997; Emebet, 2015). The carcass weight of local chickens at maturity varies from 1045 to 1292 gm for male and from 642 to 874 gm for female (Halima, 2007). About 40-70% of the chicks hatched die during the first 8 weeks of life (Tadelle and Ogle, 2001) mainly due to disease and predation. About half of the eggs produced have to be hatched to replace chickens that have died (Tadelle, 1996) and the brooding time of the laying bird is longer, with many brooding cycles required in order to compensate for unsuccessful brooding. It is estimated that under scavenging conditions, the reproductive cycle consists of 21-day incubation phase, 2 to 4 clutches and finally a 56-day brooding phase (Halima 2007; Tadelle and Ogle, 2001).

Despite the low performances of village chicken, they possess several favorable characteristics which enable them to cope-with the extensive form of management systems. They are very well adapted to harsh environment conditions, resistant to disease, have brooding ability, and depend on scavenging for feed (Harrison and Adlers, 2009; Mwale and Masika, 2009; Olwande et al., 2009; Gondwe and Wollny, 2007; Kondombo, 2005). So, it is very important to maintain their unique potentials and combine those merits in genetic improvement programs targeting development of improved breeds for low input systems.

Genetic improvement programs targeting the low input production system requires consideration of the low income level and investment power of smallholder farmers. Breeding programmes targeting the low input system like the scavenging chicken production system need to be well organized to increase the productivity of the chicken with respect to the ability to lay more eggs, grow faster and have high feed efficiency without losing the important genetic characteristics related to product qualities, disease resistance and adaptability. Setting up of breeding programmes for low input system requires the definition of clear breeding goals, which address the needs of the specific production system.

Since the past few years, the country has developed and working on broader national livestock including poultry developmnt plans such as i) Growth and Transformation Plans, ii) the Livestock Master Plan (LMP), iii) Climate Resielient Green Economy policy, iv) Livestock breeding policy, and v) livestock breeding stratagies to transform the sector. So, genetic improvement of the the animals is one of the necessay intervention to achive the set research and development goals of those aforementioned intervention plans. In this regards, developing alternative poultry breeding programs for the various chicken production systems will support and facilitate to achive the dreamed game-changing transformation goals of the poultry sector in the country.

So far, Ethiopia doesn't have comprehensive national breeding program for poultry genetic improvement. As the result, the various chicken breeding initiatives that have been implemented in the country lacks sustainability. Furthermore, the indigenous poultry genetic resources of the country have not been well exploited and improved technologies not well adopted.

Currently, there are few ongoing efforts made in the country to enhance production and

productivity of indigenous chickens through genetic improvement interventions. Among those efforts, genetic improvement activities on Horro and Necked Neck indigenous dual-purpose breeds development as well as development of DZ-White synthetic breed are good examples and successful interventions made by the Ethiopian Institute of Agricultural Research at its Debre Zeit Agricultural Research sub-station. These breed development efforts are mainly targeting the low input scavenging chicken production systems. Those efforts could bring rewarding improvements in production and productivity of indigenous chicken. However, those breeding activities have been performed with limited scope of breeding stock and target beneficiaries. Furthermore, they have not used advanced genetic improvement tools such as multi-trait index selection and assisted molecular biotechnology tools for genetic improvement interventions. As the result, the so far genetic progress achieved in improved stock of the above mentioned dual purpose breeds are not to the maximum potential, but still encouraging.

So, those ongoing breeding efforts on Horro and other indigenous chicken breed genetic improvement programs of Ethiopia targeting low input system can be further improved significantly to realize transition from subsistence type of production to market oriented one. This can be achieved through advanced breeding programs incorporating multi-trait Index selection and assisted molecular biotechnology tools as well as employing integrated approach for large-scale breed multiplication and dissemination. In the genetic improvement interventions, in addition to production traits, aspects of survival need to be addressed in the selection program since infectious diseases remain a major cause of mortality and reduced productivity. The selection program also contributes to conservation of the indigenous chicken through sustainable utilization, and to the development of lines which will be used for future hybrid chicken development targeting the family poultry. Therefore, the existing indigenous chicken genetic improvement programs need to be strengthened in terms of scope and adopting advanced selection methods like a multi-trait index selection. Even though several research works and breeding efforts have been made on genetic improvement of Horro and other indigenous chicken breeds of Ethiopia, so far, there is no well structured and sustainable breeding program in the country.

Therefore, this breeding program has been prepared for developing improved dual-purpose horro chicken breed by applying a multi-trait index selection within the breed and

the breeding program mainly targets smallholder farmers in its niche area. The same breeding program can also be used as a model breeding program (with little modifications) to genetically improve and make use of other indigenous chicken breeds and ecotypes in the country. As this newly proposed breeding program employs a multi-trait index selection and applies good practices for technology dissemination, it is expected to bring much higher genetic responses in Horro chicken and ensure sustainable dissemination and breed maintenance as well as high impact on livelihood of smallholder farmers in target farming systems.

2. EXISTING BREEDING PROGRAM OF POULTRY

Since the past few decades, several efforts have been made by different research and development institutions to improve and make use of the poultry genetic resources of the country. Many of the previous genetic improvement interventions focused on use of imported temperate breeds for crossbreeding. Some of those efforts are still going-on and showing promising results.

Attempts have been made since 1950s, to introduce different exotic layer breeds to small holder farming systems of Ethiopia with the aim of improving indigenous chicken production and productivity through crossbreeding. Those introduced breed are like White and brown Leghorns, Rhode Island Red, New Hampshire, Cornish, Australoup and Light Sussex etc. In recent years, efforts were made to import and adopt additional three layers strains namely Lohmann silver from Germany, dominant CZ from Czech and Bovan brown from the Netherlands). Those breeds were evaluated for their performance both under research station and village production environments. The crossbreeding interventions were focused on crossing of local chicken to various exotic breeds with different levels of exotic blood. Performance evaluation activity which was conducted at DZARC revealed that 62.5% white leghorn crosses showed superior performance to the locals as well as pure white leghorns in terms of egg production (DZARC, 1991). In a cross breeding program which was conducted at Assela by Brannang and Persson (1990) also compared different York x local crosses. Their results indicated that egg production declined with increasing level of exotic inheritance (above 50%). Increasing the level of exotic blood also resulted in loss of broody behavior, a trait of considerable economic value under village systems. Although the cross breeding programs produced successful results under experiment sta-

tions almost all of them were discontinued decades ago for various reasons. In the 1980s the Ministry of Agriculture initiated a cockerel distribution scheme. This involved importation and distribution of cockerels to be used as breeding males in villages. This scheme again failed because farmers were unwilling to remove their local cocks and the exotic cocks failed to adapt in the village environments. Despite those layer breed importation efforts for crossbreeding , there is no layer breed developed yet from local strain to any specific chicken farming system in the country.

Regarding efforts on Broilers poultry breed, so far, different institutions including EIAR and large commercial private poultry farms have been importing broiler breeds. Some of the imported breeds adopted in our countries are Hubbard-JV, Hubbard-classic, Rose-308 and Cobb-500. However, there is no any broiler breed developed in the country.

Among the introduced dual purpose chicken breeds in Ethiopia, the most widely used dual purpose chicken is RIR. It was used as paternal line with ISA brown layers to produce a cross bred with both traits. Fayoumi breed has been imported with the expectation of better productivity, adaptation and disease resistance than the other exotic breeds in rural setting of Ethiopia. Fayoumi was alert, adaptive layer chicken lived for many years in the warm areas of Egypt. In recent years, Koekoek was widely distributed across the country and highly liked by village producers. Recently, dual purpose Koekok breed performed well and adopted by most of smallholder farmers in the country. There are also efforts done for dual purpose indigenous Horro breed improvement through a mass selection at DZARC (Wondmeneh et al., 2015).

As compared to the layers and broilers, dual purpose chickens are well adapted to the small holder farmer conditions in Ethiopia as they adapt to wider agro-ecologies and less management requirement hence became the preferred breed type by the farmers. RIR, Fayoumi and Koekoek are the major dual purpose breeds introduced and performed well in Ethiopia. Among those introduced commercial breeds the following breeds namely Isa brown, Bovan brown, Lohmann silver, Hubbard-JV, Hubbard-classic, Rose-308 and Cobb-500 generally demand high production inputs (production costs) and thus advised to the producers, who have capacity to fulfill the requirements. On the other hand, farmers are using the dual purpose chickens (Sasso, koekoek), However, there is still a long standing

request to improve local chicken breed, which requires formally designed and structured breeding program.

Currently Horro chicken breed improvement is an ongoing research activity that has been conducted at DZARC and showing promising results. In addition to this, there is synthetic breed development (DZ-white) and Necked Necked dual purpose breed development efforts that are currently underway at DZARC. Those dual purpose breed development efforts could result in promising results. However, those breeding activities have been performed with limited scope of breeding stock and target beneficiaries. Furthermore, they have not used advanced genetic improvement tools such as multi-trait index selection and assisted molecular biotechnology tools for genetic improvement interventions. In those breeding programs, selection was performed in most cases using only two traits namely number of eggs and body weight at fixed age. As the result, the so far genetic progress achieved in those breeding are not to the maximum potentials of the breeds, but still appreciable. So, advanced breeding activities are required to further improve those dual purpose breeds to their maximum potentials through the use of advanced genetic evaluation sche es such as multi-trait Index selection considering at least egg production, growth, fertility, hatchability and survival traits.

3. CHICKEN BREED IMPROVEMENT AND CONSERVATION

3.1. Indigenous chicken breed improvement

There are different types of breeding strategies that can be applied to improve indigenous chicken including introduction of exotic breeds, crossbreeding or selective breeding within indigenous chicken (Kitalyi, 1998; FAO, 2004). Success and sustainability of each of the strategies may depend on farmers' breeding objective(s), resource availability, infrastructure, market demands, and compatibility of the genetic stock with the prevailing environmental conditions and cultural values of the society. Selection within indigenous breeds is an encouraging and viable approach for genetic improvement in the developing countries. Selection within an indigenous chicken population, called Horro has been implemented successfully in Ethiopia, and has resulted in better egg production, compared to unimproved village chicken (Wondmeneh et al., 2014; Tadelle et al., 2013). Ethiopian Horro indigenous chicken has increased egg production by 123.5% to 75 eggs by week 45

in five generations of selection for egg numbers (Tadelle et al., 2013). Although, purebred selection in indigenous chicken population require more time to improve performance than crossbreeding and breed substitution, nevertheless, it can be tailored to fit the needs of local farmers and the prevailing environmental conditions. In conclusion, the breeding program should be aimed at purebred selection utilizing indigenous chicken, as it is promising rather than breed substitution or crossbreeding.

Previous studies have indicated that indigenous chicken can be improved for meat, eggs or both due to their genetic potential (Okeno et al., 2013). Development of indigenous chicken either for meat, egg or dual purpose is accompanied by challenges. Improving indigenous chicken for meat production lowers egg production resulting in fewer eggs for hatching and subsequently fewer growers. In egg production, improving indigenous chicken for egg numbers especially selecting less broody hens is essential because it would result in more eggs for market and hatching. However, when more emphasis is placed on egg production, the weight traits are negatively affected due to antagonistic relationship between these traits. Selection of indigenous chicken either for meat or egg production is anticipated to compromise on the immune effectiveness and disease tolerance due to negative correlation between immune response with growth and egg traits. Reduction in fitness and disease immunity in turn increases the level of susceptibility and veterinary cost. Unlike meat or egg type indigenous chicken, dual-purpose chicken may have lower meat and egg production; nonetheless they are superior in fitness and immunity (Okeno et al., 2013), which are important features needed for the scavenging system. So, in designing a breeding program targeting the scavenging production conditions, the most appropriate type of chicken to use is therefore the dual purpose indigenous chicken.

To develop improved dual purpose indigenous chicken, there is a need to have clear definition of breeding objective. Farmer and consumer requirements assist in specifying which traits should be improved, and in which direction. For instance, the breeding objective for the indigenous chicken in Ethiopia has been defined in consultation with farmers, consumers & other stakeholders (Dana et al., 2010b; Okeno et al., 2011a). So, according to those authors, the breeding objective for scavenging system is to develop chicken with better production (egg number, growth rate, and body size), reproduction (fertility and mothering ability) and adaptability (disease resistance). This breeding objective is simi-

lar to the breeding objective in other African countries. Dual purpose breeding objective would produce indigenous chicken that can serve the farmer with eggs and meat beside the ability to survive under scavenging conditions.

3.2. Indigenous chicken breed/ecotypes conservation

The desire for the intensification of chicken production in developing countries like Ethiopia, through substitution with exotic chicken or crossbred has been found to increase productivity rapidly, within a short time but it has not been sustainable. Use of breed substitution tends to lead to the predominance of a few highly specialized breeds, within which the breeding goals may be narrowly focused (Thornton, 2010). The long-term process of one-sided intensive selection in exotic birds, is likely to have lowered their genetic diversity, and poor resistance to diseases. Additionally, substitution of local breeds with exotic breeds might lead to the disappearance of the indigenous breeds (FAO, 2004) and it is opposed by the global move on the conservation of indigenous genetic resources (Kosgey et al., 2006a).

Conservation of indigenous chicken genetic resources require: i) characterizing existing indigenous chicken ecotypes; 2) Identifying unique genotypes; 3) Conserving the identified unique genotypes; 4) create platform for strengthening linkage among institutions concerned with breed conservation, breed import & export as well as those working on genetic improvement. Genetic conservation can be considered as either 1) in-situ conservation where populations are maintained in their natural environments or 2) ex-situ where populations are maintained elsewhere, often in zoos or animal sanctuaries. In-situ and ex-situ conservation can be further categorized into 1) in-vivo conservation where animals are maintained live, or 2) in-vitro conservation where germplasm is cryopreserved and stored for future use. The preferred method of genetic conservation is in-situ-in-vivo conservation i.e. maintaining live animals in their natural environment, niche area.

So, in this newly proposed breeding program, the intended breeding method is within horro breed selection. So, the base population, which comprises above 87% indigenous horro chicken, will be step by step replaced by improved horro chicken breed. So, in this breeding strategy, no foreign gene will be mixed in horro gene pool so that the breeding strategy is expected to have a positive impact on horro breed conservation and maintenance.

3.3. Current status and Prospects

3.3.1.Current status of Horro chicken breed

A selective breeding program has been conducted since February 2008 G.C. to develop dual purpose Horro chicken breed at the Debre-Zeit Agriculture Research Center. Since then, a successive generation of improved Horro chicken flocks has been generated and presently there are above 1000 improved horro chicken (growers and young chicks) representing the 14th generation at DZARC. Mating has been practiced within each generation between male and female to produce new generations. Initially, the population was established from 3,000 eggs that were purchased from two village market sheds in Horro. The pedigree descended from 26 sires and 260 dams. Selection was on own performance for bodyweight at 16 weeks of age (BW16) and for the hens also on cumulative egg number at week 45 of laying (EN45).

Flock management and data recording

Birds in all age classes were provided ad libitum access to feed and water. Starting chick feed (20%CP and 2,950–3,000 kcal/kg) for the first 3 weeks and grower ration (18%CP and 2,850–2,900 kcal/kg) from 3 to 10 weeks. Between 10 and 16, 16 and 18, and from 18 weeks onward the birds were provided with pullet ration (16%CP and 2,700– 2,750 kcal/kg), pullet/layer blend and layer ration (17–18%CP and 2,700–2,750 kcal/kg), respectively. The chickens were reared in a single deep litter house until 18 weeks of age under a standard housing space, with natural lightning after 8 weeks of age. After 18 weeks of age a total of 240 females and 24 males were picked randomly and transferred to layer houses and reared in floor cages with one male and 10 females in each pen. Each pen had a trap nest for individual recording of egg production and pedigree. The remaining animals were sold due to limitations in housing space. All chickens were vaccinated against Newcastle and Marek's diseases at 1 day old, Gumboro at 1 week, and fowl pox at 10 weeks.

Live weight growth was measured every 2 weeks for the first 8 weeks then every 4 weeks for the next 8 weeks. Traits recorded were: body weights at hatch (BW0) and body weights in weeks 2 (BW2), 6 (BW6), 8 (BW8), 12 (BW12), and 16 (BW16). Age at first egg (AFE) was recorded for each hen. Early part egg production record, defined as the number of eggs

produced from housing to about 44 weeks of age, was used to study egg production traits. Egg production was recorded for six 4-week periods:21 to 24, 25 to 28, 29 to 32, 33 to 36, 37 to 40, and 41 to 44 weeks of age. Each of these 4-week intervals comprisedthe monthly records of egg numbers: M1, M2, M3, M4, M5, and M6, respectively. The cumulative of monthly egg production records were used for analyzing part period production. The number of eggs produced in periods 1 (EP12), 2 (EP36), and 3 (EP16) were the cumulative number of eggs produced from months 1 to2, 3 to 6 and 1 to 6, respectively. Box-Cox transformation was used to achieve normality in egg production data (Besbes et al. 1993). Horro chicken performance reported in this study which was conducted by Dana et al. (2011) are presented ias follows (Table 1-6).

Performance of Horro breed in generation 4

Table 1. Means of body weights of horro chicken by sex and forboth sexes combined

trait	n	Mean (SD)
BW0	642	24.9 (0.13)
BW2	642	59.6 (0.46)
BW4	641	113.9 (1.10)
BW6	640	181.6 (1.58)
BW8	606	277.8 (2.60)
BW12	528	485.5 (5.97)
BW16	388	701.1 (12.13)
Female		
BW0	872	24.6 (0.10)
BW2	871	52.2 (0.37)
BW4	871	93.4 (0.87)
BW6	870	146.0 (1.31)
BW8	849	216.0 (2.19)
BW12	764	388.3 (4.51)
BW16	646	572.7 (7.27)
Both sexes combined		
BW0	1,514	24.7 (0.08)
BW2	1,513	55.4 (0.30)
BW4	1,512	102.1 (0.73)
BW6	1,510	161.1 (1.10)
BW8	1,455	241.8 (1.86)
BW12	1,292	428.0 (3.85)
BW16	1,034	620.9 (6.71)

[a] BW0, hatch weight; BW2, BW4, BW6, BW8, BW12, and BW16, bodyweights at 2, 4, 6, 8, 12, and 16 weeks of age, respectively

[b] Number of animals; Source Dana et al. (2011)

Table 2. Mean monthly and cumulative number of eggs, hen-day (hdp) and hen-housed (hhp) rates of egg production and mortality duringthe early part laying period

Trait	Period (week)	Hens housed, n	Mean, n (±SE)	HDP (%)	HHP (%)	Mortality (%)
M1	21–24	328	0.71 (0.13)	2.53	2.34	7.6
M2	25–28	303	4.06 (0.33)	14.50	12.87	11.2
M3	29–32	269	7.82 (0.41)	27.93	26.69	4.5
M4	33–36	257	8.98 (0.44)	32.07	30.82	4.0
M5	37–40	247	8.25 (0.44)	29.47	28.51	3.2
M6	41–44	239	7.34 (0.39)	26.23	25.57	2.5
EP12	21–28	328	4.78 (0.41)	8.68	7.12	18.0
EP36	29–44	269	31.77 (1.31)	30.31	26.26	13.4
EP16	21–44	328	33.64 (1.56)	23.55	16.73	29.0
AFE		203	190.00 (1.77)			

AFE age at first egg (in days)

a M1, M2, M3, M4, M5, and M6, egg numbers in the first, second, third, fourth, fifth, and sixth months, respectively

b EP12, EP36, and EP16, cumulative number of eggs produced from months 1 to 2, 3 to 6, and 1 to 6, respectively. Source Dana et al. (2011)

Table 3. Variance components and heritability of body weight in horro chickens

Trait	Animals, n	Records, n	Sires, n	Dams, n	σ_a^2	σ_c^2	$\sigma^2 e$	h^2 (±SE)	c^2 (±SE)
BW0	1,456	1,307	25	143	3.9	3.7	2.0	0.40 (0.23)	0.39 (0.10)
BW2	1,434	1,306	25	142	19.1	11.4	71.7	0.19 (0.11)	0.11 (0.05)
BW6	1,330	1,303	25	141	197.4	43.8	1,073.3	0.15 (0.08)	0.03 (0.03)
BW8	1,262	1,248	25	138	516.9	36.6	2,643.2	0.16 (0.08)	0.01 (0.03)
BW12	1,092	1,090	25	136	2,399.0		12,410.0	0.16 (0.05)	–
BW16	845	845	25	132	9,673.0		33,220.0	0.23 (0.06)	–

a σa2 , σc2 , and σ2 e, additive genetic, common environmental, and residual variances, respectively

b h2 and c2 , heritability of direct genetic and common environmental effects, respectively

c BW0, hatch weight; BW2, BW6, BW8, BW12, BW16, body weights at 2, 6, 8, 12, and 16 weeks of age, respectively. Source Dana et al. (2011)

Table 4. Variance components and heritability of monthly and cumulative egg numbers

Trait (±SE)	Period (weeks)	Animals, n	Records, n	Sires, n	Dams, n	σ_a^2	$\sigma^2 e$	h^2
M1	21–24	203	176	23	69	0.1	0.2	0.32 (0.13)
M2	25–28	203	176	23	69	2.6	10.2	0.20 (0.16)
M3	29–32	203	176	23	69	15.5	12.2	0.56 (0.15)
M4	33–36	203	176	23	69	7.1	21.8	0.25 (0.14)
EP12	21–28	203	176	23	69	3.8	11.9	0.24 (0.16)
EP36	29–44	203	176	23	69	67.6	174.3	0.28 (0.15)
EP16	21–44	203	176	23	69	115.9	216.5	0.35 (0.16)
AFE		203	176	23	69	31.5	458.5	0.06 (0.15)

AFE age at first egg (in days)

a σ 2 , σ 2 , and σ2 e, additive genetic, common environmental, and residual variances, respectively

b h2 , heritability of direct genetic and common environmental effects, respectively

c M1, M2, M3, and M4, egg numbers in the first, second, third, and fourth months, respectively d EP12, EP36, and EP16, cumulative number of eggs produced from months 1 to 2, 3 to 6, and 1 to 6, respectively. Source Dana et al. (2011)

Table 5. Genetic (below diagonal) and phenotypic (above diagonal) correlations

Trait	BW0	BW2	BW6	BW8	BW12	BW16	EP12	EP36	EP16
BW0		0.45 (0.03)	0.22 (0.03)	0.15 (0.03)	0.09 (0.03)	0.10 (0.03)	0.06 (0.08)	0.19 (0.07)	0.19 (0.08)
BW2	0.71 (0.08)		0.64 (0.02)	0.53 (0.02)	0.37 (0.03)	0.27 (0.03)	0.16 (0.07)	0.07 (0.08)	0.13 (0.08)
BW6	0.46 (0.10)	0.85 (0.06)		0.85 (0.01)	0.59 (0.01)	0.40 (0.03)	0.25 (0.07)	0.16 (0.07)	0.21 (0.07)
BW8	0.37 (0.11)	0.77 (0.08)	0.97 (0.02)		0.74 (0.01)	0.56 (0.02)	0.19 (0.07)	0.11 (0.08)	0.15 (0.07)
BW12	0.25 (0.13)	0.54 (0.13)	0.68 (0.11)	0.86 (0.06)		0.82 (0.01)	–	–	–
BW16	0.30 (0.12)	0.51 (0.13)	0.67 (0.12)	0.82 (0.08)	0.99 (0.03)		0.35 (0.07)	0.31 (0.07)	0.38 (0.06)
EP12	0.30 (0.38)	0.22 (0.48)	−0.54 (0.93)	–	–	0.92 (0.35)		0.39 (0.06)	0.59 (0.05)
EP36	0.40 (0.36)	−0.16 (0.56)	–	–	–	0.69 (0.43)	0.80 (0.32)		0.96 (0.01)
EP16	0.42 (0.31)	0.02 (0.46)	–	0.15 (0.07)	–	0.73 (0.32)	0.88 (0.21)	0.98 (0.02)	

a BW0, hatch weight; BW2, BW6, BW8, BW12, and BW16, body weights at weeks 2, 6, 8, 12, and 16, respectively

b EP12, EP36, and EP16, cumulative number of eggs produced from months 1 to 2, 3 to 6, and 1 to 6, respectively. Source Dana et al. (2011)

Table 6. Genetic (below diagonal) and phenotypic (above diagonal) correlations between monthly and cumulative number of eggs produced during the early part laying period

Trait	M1	M2	M3	M4	Ep12	Ep36	Ep16
M1		0.38 (0.06)	0.10 (0.07)	0.18 (0.07)	0.48 (0.05)	0.22 (0.07)	0.38 (0.06)
M2	–		0.40 (0.06)	0.16 (0.07)	–	0.39 (0.06)	0.59 (0.04)
M3	0.29 (0.37)	0.94 (0.32)		0.25 (0.07)	0.39 (0.06)	0.58 (0.04)	0.59 (0.04)
M4	−0.15 (0.47)	0.71 (0.52)	0.97 (0.39)		0.16 (0.07)	0.73 (0.03)	0.68 (0.04)
EP12	–	–	0.83 (0.26)	0.46 (0.45)		0.39 (0.06)	0.59 (0.05)
EP36	0.16 (0.46)	–	–	0.81 (0.19)	0.80 (0.32)		0.96 (0.01)
EP16	0.38 (0.37)	–	–	0.74 (0.21)	0.88 (0.21)	0.98 (0.02)	

a M1, M2, M3, and M4, egg numbers in the first, second, third, and fourth months, respectively

b EP12, EP36, and EP16, cumulative number of eggs produced from months 1 to 2, 3 to 6, and 1 to 6, respectively. Source Dana et al. (2011)

Performance of Horro breeds in generation 6

The study performed in generation 6 of Horro breed revealed that body weight at 16 weeks of age has a strong genetic correlation with the total number of eggs recorded from housing to 44 weeks of age. These two traits also showed higher level of heritability, relative to their respective trait categories. The egg production of improved horro chicken was increased from 34 to 76 eggs in 6 month. This change was recorded after 6 generations. Heritability for BW16 in the 6th generation (G6) was 0.37, and for EN24 was 0.32. Phenotypic correlation between BW16 and EN24 was 0.36, but genetic correlation was -0.12. Genetic correlations of BW16 with cumulative egg production earlier in the laying series were 0.51 at 8 weeks of laying, decreasing to 0.22 at 16 weeks of laying. The genetic trends were positive for both traits under selection from generation 4 (G4) and G6. Table 7 – 9 contain detail information on the Horro chicken performance in generation 6 as reported by Esatu and Dessie (2019).

Table 7. Means, SD, minimum, maximum, and numberof observations of the traits in g4 & g6

Gen.	Traits	n	Mean	SD	Min.	Max.
G-4	EN8	1307	6.7	3.5	4	18
	EN16	1139	17	11.2	11	54
	EN24	1014	63	24.6	42.4	93.5
	BW12	1758	516	127.8	321	916
	BW16	1389	689	212.5	500.5	1290
G-6	EN8	1367	13.6	5.5	11	29
	EN16	1291	24.6	12.7	21.6	71
	EN24	1251	76	28.6	71	101
	BW12	1709	572	310.5	412	1432
	BW16	1451	1211	211.2	1110	1760

EN8, EN16, EN24= cumulative egg number in 8, 16 and 24 weeks after onset of laying; BW12 and BW16 = body weight at 12 and 16 weeks of age. Source: Esatu and Dessie (2019)

Table 8. Estimates of heritability of direct effects (h^2) forweek 16 body weight and cumulative egg number in 24 weeks after onset of laying (en24)

Traits	h2
BW16	0.37(0.05)
EN24	0.32(0.08)

BW16= body weight at 16 weeks of age; EN24= cumulative eggnumber in 24 after onset of laying. Source: Esatu and Dessie (2019)

Table 9. Phenotypic and genetic correlations among eggproduction and body weight traits

Traits	BW12	BW16
Phenotypic correlations		
EN8	0.35 (0.20)	0.36 (0.54)
EN16	0.41 (0.09)	0.23 (0.21)
EN24	0.32 (0.10)	0.36 (0.21)
Genetic correlations		
EN8	0.54 (0.31)	0.51 (0.12)
EN16	0.27 (0.43)	0.22 (0.30)
EN24	0.34 (0.43)	-0.12 (0.21)

Source: Esatu and Dessie (2019)

3.3.2. Prospect of Horro chicken breed

In the Livestock Master Plan (LMP), strategies were set to upgrade the smallholder poultry

production (scavenging system) into improved family poultry production (IFP) with standard poultry package and replace the unproductive local strains by improved dual-purpose breeds. In the IFP system, smallholder farmers are supposed to receive a package having a days old improved dual-purpose chicks, feed, veterinary inputs, training, and brooding hey box. The smallholder farmers prefer to have dual purpose chicken breeds and this was supported by LMP. Although there are some previously imported dual purpose chicken breeds such as Sasso and Koekoek that can be used in the IFP systems, it is very advisable to produce locally adapted and well producing dual purpose chicken breed from local ecotypes. This will ensure sustainable supply of improved chicken breed in the country.

The Horro chicken breed can be one potential indigenous breed that can be improved through selective breeding targeting IFP system. This was confirmed by the findings of several previous studies that are discussed in various sections of this document. According to the findings of those studies, the Horro chicken breed showed very good genetic response for growth and egg production traits through selective breeding. So, the breed has good prospect to serve as animal of choice in IFP system. For this, a well-organized breeding scheme (selective breeding) is needed to maintain and use improved dual-purpose Horro as pure line. So, this newly proposed breeding program has been designed to improve the horro chicken for dual purpose through within breed selection.

The second option is to improve the genetic potential of horro chicken breed through crossbreeding. This can be performed by crossing improved Horro with imported layers, broilers and dual purpose chicken breeds. Such crossbreeding leads to development of crossbreds or synthetic breeds targeting IFP system. For instance, the following breeding plan with four stages crossbreeding program can be successful in Ethiopia in producing dual purpose chicken breed with combined potentials for egg production, growth and disease resistance (Ralph et al., 2011). Those four stages to be followed are: 1) Selective breeding of the indigenous horro chicken for egg production; 2) Cross-breeding of the selected indigenous horro hens with cocks of layer line, e.g. White Leghorn, leading to Crossbred offspring (C1). This offspring is expected to lay more and bigger eggs than the indigenous chickens; 3) Cross-breeding of the C1 hens with selected broiler cocks (Sasso) to get the 2nd crossbred offspring (C2); The C2 birds have the ability to grow faster and put on more meat,

and at the same time lay more eggs than the indigenous chickens; 4) Cross-breeding of the C2 hens with selected indigenous horro Cocks to introduce more disease resistance in the required crossbreeds (C3) offspring, while retaining the ability to grow fast, put on more meat and lay more eggs. C3 is the desired end product of the breeding plan.

On the other hand, production of pure lines for egg or meat production is one prospect of using horro chicken. For instance pure line development for laying performance can be approached by the following three steps: 1) Selective breeding of the indigenous horro chicken for egg production; 2) Cross-breeding of the selected indigenous horro hens with cocks of layer line, e.g. White Leghorn, leading to Crossbred offspring (C1). This offspring is expected to lay more and bigger eggs than the indigenous chickens; 3) Cross -breeding of the C2 hens with selected indigenous horro Cocks to introduce more disease resistance in the required crossbreeds (C3) offspring, while retaining the ability to grow fast, put on more meat and lay more eggs.

Similarly, production of pure lines for meat production can be approached by the following three steps: 1) Selective breeding of the indigenous horro chicken for meat production; 2) Cross-breeding of the selected indigenous horro hens with cocks of broiler line, e.g. , leading to Crossbred offspring (C1). This offspring is expected to lay more and bigger eggs than the indigenous chickens; 3) Cross -breeding of the C2 hens with selected indigenous horro Cocks to introduce more disease resistance in the required crossbreeds (C3) offspring, while retaining the ability to grow fast, put on more meat and lay more eggs.

4. CHARACTERIZATION OF TARGET SITE AND BREEDS

4.1. Characterization of target sites

Horro district which is located in the western Oromia regional state of Ethiopia (Figure 1), is the primary target area for which this model breeding program is initiated with the aim of genetically improving the existing indigenous chicken 'Horro,' of the district. For this, the proposed breeding program has been directed towards developing improved dual purpose Horro Chicken breed through within breed selection. As shown in Tabel 10, Horro district has an altitude ranging from 2580–2810 m.a.s.l. and annual rain fall of 1200 – 1800 mm. The mean annual temperature is 22 – 26 °C. The district has 84,596 human population size with 14099 Households each with an average of 6 family size. The major

ethnic community of the area is Oromo. Regarding crop and livestock agricultural practices, farmers in the area produce Cereals (wheat, maize, teff, barley) and Pulses (field pea, faba bean)Oil crop (noug) crops. Those livestock species kept by Horro farmers are Cattle, Sheep, Goats, Poultry and Fishes.

Table 10. Ecological and demographic characteristics of horro chicken rearing area

Ecology	Tepid to cool wet highland
Altitude (range, m asl., for sampling sites)	2580–2810
Annual RF (mm)	1200–1800
Mean annual temp. (°C)	22–26
Human population	84 596
Av. family size	6
No. Household	14099
No. of chickens, total	34 991
No. of local chickens	29 780
No. of exotic chickens	5 211
Major ethnic community	Oromo

Source: Dana et. al.(2010)

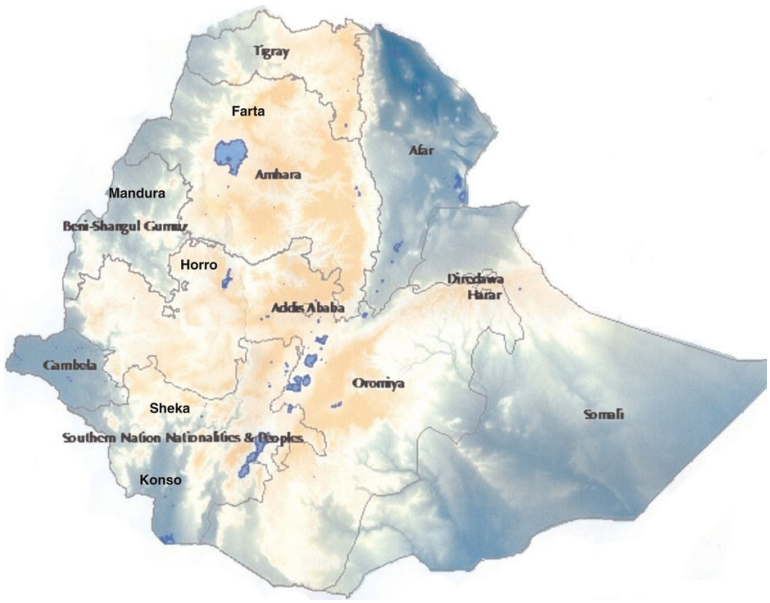

Figure 1 a map of Ethiopia showing the location of horro chicken populations.

Source: Dana et. al.(2010)

4.2. Characterization of the breed

Horro is an indigenous chicken type named after the geographic region of origin located in the western part of Oromia regional state of Ethiopia near the Blue Nile gorge. Horro chickens live at altitudes ranging from 2 580 to 2 810 m asl in a tepid to cool wet highland ecological zone and raised by the Oromo ethnic community (Table 10). There is about 30,000 chickens restricted to this the geographic region (Dana et al. 2010).

Horro chickens are reared under scavenging management with supplemental feeding, and in most cases the birds are sheltered in the family house during the night (D. Nigussie et al., unpublished data). The population has a wide range of morphologic and genetic diversity. The single most important plumage colour of males is red (60 per- cent). Only 3 percent of the females are red and the most frequent colour is zigrima, which is totally absent in males. All chickens have feathered necks. Yellow is the dominant skin colour in both sexes. The predominant body shape is blocky. However, quite a large proportion of cocks (22%) have a triangular body shape (Table 11). The average shank length of adult males is 8.8 cm and that of females is about 6.8 cm. Adult males weigh about 1700 g and females 1372 g (Table 12).

Table 11. Morphometric characters of horro chicken populations

Morphometric characters	Horro (%)
Feather morphology	
Normal	66
Silky	34
Feather distribution	
Normal	100
Naked neck	0
Skin colour	
White	35
Yellow	65
Shank colour	
White	31
Black	12
Yellow	57
Earlobe colour	
White	52
Red	45
Yellow	3
Comb type	
Single	13
Rose	14
Pea	56
Walnut	4
Duplex	13
Head shape	
Snake head	23

Crest	33
Flat	44
Body shape	
Blocky	90
Triangular	8
Wedge	2

Source: Dana et. al.(2010)

Table 12. Adult live body weight and shank length of indigenous horro chicken

Traits	Sex of birds	Weight (g)
Live weight (g/bird, ±SD)	Male	1 700 (437)
	Female	1 372 (344)
Shank length (cm, ±SD)	Male	8.8 (1.0)
	Female	6.8 (0.6)

Source: Dana et. al.(2010)

5. Breeding Objective

5.1. General objective

To develop model dual-purpose chicken breeding programs that contribute to enhanced indigenous chicken production and productivity, increased income of smallholder farmers, job creation, conservation of genetic resources, export market, and also be adopted to other breeds and ecotypes

5.2. Specific objectives

- To develop standard dual-purpose breeding program for indigenous horro chicken that enhances egg and meat production and productivity sustainably and contributes to household and national income

- To design model breeding program enabling participation of smallholder farmers and conservation of indigenous chicken biodiversity

To sustainably avail improved dual-purpose horro chicken breed technology for semi-intensive and extensive management systems

- To advance knowledge and skills on designing and implementation of alternative breeding programs that support development of improved chicken breeds from indigenous breeds and ecotypes

5.3. Breading goal and traits

The dual purpose Horro chicken breed improvement program aims at maximizing genetic gain both for egg production and growth traits keeping the level of inbreeding to the lowest possible in the population. In this breeding program, the breeding goal traits and improvement strategy that were proposed by Menge (2008) for African indigenous chicken genetic improvement programs can be applied for developing improved dual-purpose Horro chicken breed from already existing advanced generation (G14) of the Horro flock that are kept at Debrezeit Agricultural Research Center. As proposed by the author, simple breeding goals for indigenous chicken can be defined taking into account the nature of the production systems and the background of the smallholder farmers. The number of traits to be selected for can be reduced by assuming a line breeding approach whereby few characters are selected for within a line and cross breeding done to get the commercial stock.

Thus, the traits proposed to be included in breeding goal are number of eggs per clutch or at 45 weeks of age (NECl), live-weight of cockerels (LWc) and pullets (LWp) at 16 weeks of age, age at first egg (AFE), egg weight (EW) at 45 weeks of age, and Survivability until age of first egg laying (GSR). So, in this breeding program, a minimum of 1% increment in each of those traits is expected as genetic response per generation. Besides choosing those goal traits based on the recommendation of Menge (2008), they were subjected to economic value and genetic gain responses using bio-economic model and SelAction program, respectively. Furthermore, those chosen goal traits for the development of dual purpose Horro chicken breed are in strong agreement with the recommendations of several previous studies targeting indigenous chicken breed development as well as existing breed selection practices and trait preference of Ethiopian smallholder poultry farmers (Dana et al., 2011).

Traits expressed in the hens such as NeCl, AFE, and CSR will be improved through the dam lines while all production traits namely EW, LWc and LWp, are to be improved through the sire line in a breeding program.

6. Selection criteria and schemes

6.1. Selection criteria

In this breeding program, the computer program SelAction (Wagenengen University, 1997) was used to determine selection criteria and genetic gain. The information sources for selection are data on individual animal itself, half sibs, fulll sibs, progeny, sire and dam. Furthermore, due consideration was given to economically important traits for farmers and the interest of government development policy in setting selection criteria.

So based on the SelAction results, females will be selected based on mass selection (own performance) and pedigree information (BLUP); whereas, males will be selected based on pedigree information. Males with progenies having breeding values within the top 25% for growth and egg production as well as Males with progenies having survival average in top 25 percent will be selected as parent of next generation. Survival of progenies to until age at first egg laying (24 weeks) of age will be considered.

So, in foundation stock, selection will be practiced at 45-week of age, on the basis of an index comprising the parameters of age at first egg (days), body weight (g) at 16 weeks of age, total egg production until 45 weeks of age and egg weight (g) at 45 weeks of age.

The selection Index will be computed by the following equation:

Selection Index (I) = $b_1x_1 + b_2x_2 + \ldots + b_nx_n$

Where, $x_1, x_2, \ldots\ldots x_n$ represent the phenotypic value for the traits and $b_1, b_2, \ldots b_n$ denote the relative weight given to each of the traitSo, the total score that will be obtained from above calculation is a selection index. The individual with the higher total score will be selected for breeding purposes. Both index selection and independent culling levels will be used to select chicken.

Additional considerations suggested by Ngeno (2015) and Dana et al (2011) need to be considered in developing dual purpose Horro Chicken breed for low input systems in Ethiopia. According to those authors, chicken morphological characteristics like plumage colour, comb type, and feather morphology, may affect farmers and consumer's perception, preferences, adoption and the financial value of the chicken.

6.2. Genetic and phenotypic parameters for goal traits

Literature values of genetic parameters such as heritability and correlation can be used to construct selection indexes and breeding values of indigenous chicken. Different values of those parameters were reported in several studies. However, the genetic parameters for goal traits in local ecotypes are expected to fall in range between the values reported in various literatures. For instance, heritability values of 0.42 to 0.52, 0.31 to 0.69, and 0.28 to 0.6 were reported for age at first egg, egg number, and egg weight, respectively, in different outbred chicken (Buitenhuis et al., 2004; Hartmann et al., 2003; Lwelamira et al., 2009; Wie and Werf, 1995). Heritability values of 0.03 to 0.21 and 0.18 to 0.42 were reported for number and weight of eggs, respectively, in crosses generated from inbred chicken lines (Goraga et al., 2010).

Understanding the level and direction of correlations between traits of economic importance is crucial to set appropriate breeding programs. Traits with high positive genetic and phenotypic correlations can be improved together genetically. In other words, genetic improvement for one trait can also improve the other trait. However, negative correlation between traits leads to opposite direction of improvement.

Sexual maturity of hens is negatively correlated to number of eggs, egg production rate, and body weight. Egg number and egg weight also show negative correlation. The body weight of hens positively correlates with egg weights and number of eggs (Francesch et al., 1997; Goraga et al., 2010; Kamali et al., 2007).

So, the following three tables (Table 13 - 15), presents the phenotypic and genetic parameters as well as the economic values of goal traits used for setting selection criteria for dual purpose horro chicken.

Table 13. Goal traits, phenotypic variance (σp2), genetic variance (σ2a) and heritability (h2)

	Varp	Varg	h2
EN	576	70.52	0.35
EWT	30	8.81	0.36
AFE	196	31.5	0.31
BW	3,691	2178	0.37
SR	81	10	0.12

Table 14. Goal traits, phenotypic (upper triangle) and genetic (lower triangle) correlations

	EN	EWT	AFE	BW	SR
EN	1	-0.18	-0.09	0.38	0.2
EWT	-0.29	1	-0.22	0.23	0.32
AFE	-0.41	0.24	1	-0.48	0.2
BW	0.69	0.42	-0.22	1	0.34
SR	0.25	0.3	0.25	0.4	1

Table 15. Goal traits, economic value (in birr), standard economic weight and their relative importance

Traits	Current performance	after improved by 1%	EV	genetic STD	EV x genetic STD	Trait relative importance
EN per clutch	51	51.51	0.1005	8.40	0.84	6.53
EW(g)	45	45.45	-0.0185	2.97	-0.05	-0.43
AFE	165	163.35	0.0155	5.61	0.09	0.67
BWav	1.35	1.3635	0.2495	47.00	11.73	90.76
SR	95	95.95	0.1005	3.16	0.32	2.46

6.3. Selection path /groups

In this breeding program, there will be breeding (main nucleus at DZARC) and production (commercial producers and smallholder farmers) units. Bako and Ambo research centers will act as the main multiplication and dissemination centers. The following six optional selection groups can be considered in development of hens and cocks targeting those breeding and/or production groups. Generation and dissemination of genetic gains occur

in the breeding and production units, respectively.

The selection groups:

1. Cocks to produce breeding Cocks where Cocks selection occurs to improve the Cocks used in the nucleus breeding unit,

2. Cocks to produce breeding Hens where Cocks selection occurs to improve the Hens used in the breeding unit,

3. Hens to produce breeding Cocks where Hens selection occurs to improve the Cocks used in the breeding unit,

4. Hens to produce breeding Hens where Hens selection occurs to improve the Hens used in the breeding unit,

5. Cocks to produce breeding Hens where Cocks selection occurs to improve the Hens used in the production unit (production groups and base population)

6. Hens to produce breeding Hens where Hens selection occurs to improve the Hens used in the production units (production groups and base population). Transmission of genetic gain to the production unit is only through the selection group in the top nucleus.

the top nucleus.

However, in this specific breeding program, a simple selection strategy will be adopted where improvement efforts will be concentrated on one nucleus flock at DZARC with two lines, the Dam line will be selected for Age at first egg (AFE), Survivability until age of laying first egg (SR), and Number of eggs (EN) until 45 weeks of age (1st clutch production); while, the Sire line will be selected based on egg weight (EW), live weight of Cockerels (LWc) and Pullets (LWp) at 16 weeks of age.

7. Market and economic values of traits

7.1. Market

Market is one of the key factors to be considered in designing breeding program which aims enhancing production. So, there should be alternative options to get good access to the nearby small markets as well as to the big markets that are found in big cities and towns. A market might also need to be built-up around production units.Generally, indigenous chicken breed improvement, multiplication, dissemination and marketing can be more effective by encouraging different stakeholders such as farmers, youth groups or pri-

vate companies to form enterprises depending on their interests and objectives. Formation of enterprises, leads to specialization of production in the indigenous chicken value chain, which can be more effective, unlike the customary poultry production, where each farmer is being involved in all the stages of production. Moreover, development of enterprises allows intensification of indigenous chicken production and marketing, resulting in sustainable indigenous chicken enterprises and subsequently the breeding program. Enterprises that can be formed are hatchery, chick, grower and mature chicken keepers as well as processors. Different enterprises are encouraged to form mutual contract agreements, so that output in one enterprise is input in another.

7.2. Economic values of traits

In designing breeding program, it is necessary to identify economically important traits in target breed and farming system. For this, information on economic weights of breeding goal traits is derived and used as an input in selection index. So, a bio-economic model which relates biological traits of Horro chicken (Table 16 - 17) with the financial result of the production system was constructed using Microsoft Excel spread sheets for the purpose of driving economic values (Table 19) of goal traits. As income source, only the tangible (direct regular cash income from sale of eggs, grower cockerels, pullets, culled adult hens, culled adult cocks and poultry litter) benefits of rearing Horro chicken were considered. The data used in the analysis were horro chicken production system, biological parameters, management variables, and farms revenues and expenses. The analyses performed were: 1) specifying the production system and the market; 2) making an inventory of the business revenues and expenses; 3) determining the biological traits that affect these revenues and expenses; and 4) deriving relative economic weights for identified traits. Based on this, five traits namely number of eggs, body weight, age at first egg, egg weight and survivability were identified as economically important traits in dual purpose horro chicken production and they were considered as breeding goal traits.

Table 16. Biological and management variables in horro chicken

Variables	Abbreviation	Horro performance
Biological variable		
Age at first egg (days)	AFE	165
live weight of mature male grower g)	BWmg	1.5
live weight of mature female grower (kg)	BWfg	1.2
live weight of adult hens (kg)	BWh	1.8
live weight of adult cocks (kg)	BWc	2.5
Chick survival rate (%)	CSR	90
Clutches/yr	NCl	3
Egg weight (g)	EW	45
Eggs/clutch	NeCl	51
Fertility (%)	FRT	95
Grower survival rate (%)	GSR	95
Hatchability (%)	HTC	85
Layer survival rate (%)	LSR	95
Laying percent (%)	Lpc	50
Productive lifetime (days)	PLT	525
Management variables		
formulated feed intake of chicks (g/chick/day)	Fic	32.5
feed intake of growers (g/grower/day)	Fig	72.5
feed intake of layer (g/layer/day)	Fih	115

Table 17. Biological traits influencing revenues and costs in horro chicken

Trait		Unit		Abbreviation
Age at first egg		Days		AFE
Chick survival rate		%		CSR
Feed intake of laying hens Feed intake to sale age (growers)Feed intake to sale age (chicks) Fertility		kg kg kg %		FI_h FI_g FI_c FRT
Grower survival rate		%		GSR
Hatchability		%		HTC
Layer survival rate		%		LSR
Live weight of cockerels at 16 weeks Mature live weight of cocks Mature live weight of hens Live weight of pullets at 16 weeks Number of eggs per clutch		KgKgKgKg EN		LW_c LW_m LW_f LW_p NeCl
Egg weight		G		EW
Productive lifetime		Days		PLT

Table 18. Economic variables of goal traits in horro chicken

Variable	Abbreviation	amount (birr)
Price per egg	pegg	5
price per day old chick	Pchick	10
Price per cockerel	Pcockerel	150
Price per pullet	Ppullet	80
Price per adult hen	Phen	120
Price per adult cock	Pcock	250
Meat price per kg live weight	pmeat	100
Price per kg of chick feed	pcmash	22.15
Price per kg of grower feed	pfmash	17.5
Price per kg of layer feed	Plmash	18.64
Fixed cost (feederer & water trough for the all breeder stock)	Plmash	122,520

Table 19. Economic value and relative importance of goal traits

Traits	Current performance	after improved by 1%	EV	genetic STD	EV x genetic STD	Traitrelative importance-1	Trait relative importance-2
EN per clutch	51	51.51	0.1005	8.40	0.84	6.53	6.50
EW(g)	45	45.45	-0.0185	2.97	-0.05	-0.43	0.00
AFE	165	163.35	0.0155	5.61	0.09	0.67	0.67
BWav	1.35	1.3635	0.2495	47.00	11.73	90.76	90.38
SR	95	95.95	0.1005	3.16	0.32	2.46	2.45

7.3. Prediction of expected selection response

Expected selection response for egg production, egg weight, body weight and age at sexual maturity was estimated for foundation stock using the following equation (Falconer, 1981).

$R=1/2h^2\times S_f$

where, R = Expected response in mass selection

h^2 = heritability, h^2 of EP, EW, ASM and BW

S_f = Selection differential for dam.

Table 20. Predicted genetic gain (trait unit) per generation = per year

Trait	Scheme-1	Scheme-2	Scheme-3
EN	10.423	9.712	9.504
EW	1.312	1.234	1.212
AFE	-1.450	-1.310	-1.269
BW	37.151	34.689	33.971
SR	1.378	1.294	1.27
Total response (economic unit)	10.433	9.741	9.539
Inbreeding per generation	0.0085	0.0014	0.00027

Remark: A generation interval of 1 year is assumed in horro chicken

8. DESIGNING OF BREEDING PROGRAMS

8.1. Scope of the program

This model breeding program is limited to development of improved dual purpose (egg & meat) horro chicken breed for smallholder farmers in its niche adaptive environment in the country. It addresses the technology needs of low input farmers in target area. The program will contribute to the government goal of transforming the traditional chicken producing farms into improved family poultry units through availing improved dual-purpose horro chicken breed with associated package to organized farming communities in the breed's niche area. The breed can perform well and is economical in semi-intensive and scavenging management systems in mid and highland agro-ecologies. The ultimate goal of the breeding program is to transform the livelihood of smallholder horro chicken producers through genetically improving the breed and enhance its production and productivity for objective traits. This breeding program can be used as a guideline to design similar breeding programs for other indigenous chicken breed or ecotypes in Ethiopia.\

8.2. Evaluation of schemes

Before deciding a specific breeding scheme for dual purpose Horro breed genetic improvement, dissemination and maintenance, three different schemes were evaluated based on several criteria such as degree of response to selection, rate of breed technology dissemination, economics, and rate of inbreeding (Table 21).

The evaluated schemes are:

1) a 1-tier closed nucleus breeding scheme, which will be established at Debre - Zeit Agricultural Research Center (DZARC) with 50 Cocks and 500 Hens (breeding stock). The nucleus will serve as a point of intensive genetic evaluation, selection and maintenance. Currently there are above 1000 horro chicken (growers and chicks) representing the 14th generation of improved horro chicken breed at DZARC. So, this flock can be used to choose 50 cocks and 500 hens for establishing foundation breeder stock for this breeding program. Those selected 500 hens will be used to produce young growers for flock maintenance and dissemination to farmers. This stock at DZARC will be further genetically improved by culling 25% of the adult stock (hens & cocks) annually and replace the culled ones by new generation progeny with superior performance for goal traits. Each beneficiary farmer will be provided with 25 young growers (20 females and 5 males).

The 2nd proposed scheme is a 2-tier closed nucleus breeding scheme where Tier-1, the main nucleus (DZARC) with 50 Cocks and 500 Hens (breeding stock) will serve as a point of intensive genetic evaluation, selection and maintenance; whereas, in tier-2, the regional multiplication and rearing centers (RMRCs) e.g. Bako RC and Ambo RC at Ginchi sub-center, will serve as center of multiplication (hatching), rearing the chicks until 3 months old and dissemination to farmers. In this 2-tier scheme, the RMRCs will also maintain 100 cocks and 1000 hens as breeder stock and have recording at least for few easily measured traits. So, it can be possible to make partial breed evaluation and selection also at RMRCs. Every year, RMRCs will collect several thousands of fertile eggs both from their own horro breeder stock and also from tier-1 (DZARC). Afterwards, they will hatch all those collected fertile eggs and rear the chicks until 3 months of age. After retaining few young growers for their flock replacement, the RMRCs will disseminate all the remaining productive young growers to smallholder farmers,. They will repeat this process every year.

The other proposed breeding scheme is a 3rd scheme, which is a 3-tier closed nucleus scheme. In this scheme, there will be a 3rd additional unite called tier-3, where several model farmers in horro district will be organized into breeder groups. The main role of those organized breeder groups will be to produce and sale fertile eggs of improved horro breed to smallholder farmers in base population and also for youth groups organized as commercial producers (chicken micro-enterprise). Although, the main form of breed technology dissemination is in form of fertile eggs, the breeder groups can also disseminate the technology in form of chicks, growers and adult hens and cocks. So, every year, a minimum of 10 breeder groups of model farmers each with 25 members will be established by NAGII in collaboration with the RMRCs and other key stakeholders. Each member in the breeder group will receive and rear 25 young grower chicken (5 male & 20 female). Each year, members of the newly organized breeder group will receive young grower chicken from the RMRCs and raise the young growers for the purpose of egg production. So, the breeder groups will serve as the main point of disseminating fertile eggs of improved hoor chicken breed to smallholder famers and commercial micro-enterprises.

Comparing the three different schemes, like the 1st and 2nd schemes, the 3rd scheme has relatively similar genetic responses (Table 22) for goal traits and very low rate of inbreeding which is 0.00027 per generation but it has the following comparative advantages as

compared with the other two schemes. For instance, 1) unlike in the other two schemes, in the 3rd scheme, there is high rate of improved horro chicken breed dissemination, i.e., in this scheme, every year, it will be possible to reach above 2917 smallholder farmers with 25 chicken package (5 cocks & 20 hens) as compared with the 487 and 1666 number of farmers that can be reached by scheme-1 and scheme-2, respectively ; 2) the scheme has a minimum of 1 million birr higher profit in dual purpose horro chicken production as compared with the annual profit in scheme-1 and scheme-2 (Table 21); Furthermore, the 3rd scheme allow participation of several farmers and other community groups in horro chicken breeding and marketing process as compared with the 1st and the 2nd schemes.

Table 21. Comparative evaluation of the three breeding schemes

Sr.N	Evaluated parameters	scheme-1	scheme-2	scheme-3
1	no of breeder hens maintained	500	1500	6500
2	no of breeder cocks maintained	50	150	1400
3	no sold eggs	0	0	172603.1
4	no sold male growers	9736	43256	102528
5	no sold female growers	9736	43056	101390
6	no sold adult cocks	25	75	388
7	no sold adult hens	125	375	1625
8	total income	3,614,687.48	15,969,475.51	19,863,591.57
9	total cost	1,266,244.73	4,050,917.50	6,330,155.88
10	total profit before tax	2,348,442.75	11,918,558.01	13,533,435.70
11	total profit after tax	1,996,176.34	10,130,774.31	11,503,420.34
12	no farmers to reach with 25 chicken package (20 hens & 5 cocks)	487	1666	2917

Table 22. Predicted genetic gain (trait unit) per generation (per year) in the three schemes

	Trait	Scheme-1	Scheme-2	Scheme-3
	EN	10.423	9.712	9.504
	EW	1.312	1.234	1.212
	AFE	-1.450	-1.310	-1.269
	BW	37.151	34.689	33.971
	SR	1.378	1.294	1.27
	Total response (economic unit)	10.433	9.741	9.539
	Inbreeding per generation	0.0085	0.0014	0.00027

Remark: A generation interval of 1 year is assumed in chicken

Profit at Household level

Table 23. Annual profit at household level (breeder farmers) in scheme-3

Parameters	Amount or quantity	Assumptions
no hens maintained per household	20	25 breeder stock: 20 hens & 5 cocks
no eggs produced/HH/Yr	1,454	Layer survival=95%, laying rate=50%, nr of clutch=3, eggs/clutch=51)
no egg after 5% loss	1,381	Egg loss=5%
no eggs sold per HH/yr	690	50% of remaining
No eggs used for hatching	690	50% of remaining
no of survived mature growers	477	Fertility=95%, hatchability of fertile egg=85%, chick survival=90%, Grower survival rate=95%
no male mature growers	238	Sex ratio 50% M & 50% F
no female mature growers	238	Sex ratio 50% M & 50% F
income from egg sale	3,452.06	One egg sold for 5 birr
income from sale of male mature growers	35,750.21	Cockerel cost 150 birr
income from sale of female mature growers	19,066.78	Pullet cost 80 birr
total income	58,269.05	
total Cost (feed + other fixed cost)	33,796.05	Assumed to be equal to 58% of total income
Profit per HH per yr (birr)	24,473.00	

8.3. Selected scheme

After evaluating those three breeding schemes, the 3rd scheme, which is a 3-tier closed nucleus scheme was found to be the most appropriate for Horro breed improvement, dissemination and maintenance in its niche area. In this scheme, genetic gain is generated in tier-1 (DZARC) and transferred to tier-2 Bako RC and Ambo RC (Ginchi sub-center) for multiplication (hatching), rearing until 3 months of age and disseminating to tier-3 (breeder farmers groups). Genetic materials of improved horro chicken breed will be transferred from DZARC to RMRCs (Bako and Ambo RCs) in form of fertile eggs, whereas from RMRCs to breeder farmers (tier-3) in form of 3 months old chicks. A job creation intervention will also be made for jobless youth groups to raise day old chicks and sale them at age of 3 months old. So, the breeder farmer groups will sale their fertile eggs to organized youth groups. Those youth groups will be organized as commercial producers (micro-enterprise)

to raise at least 1000 day old chicks per micro-enterprise and sale them in the local markets at the age of 3 month old. The youth groups will be linked to the RMRCs to get access for hatchery facilities so that they can hatch their fertile eggs at RMRCs. So, in this 3-tier closed nucleus system, those smallholder farmers who are not part of the breeder groups, will receive genetic materials of horro chicken in form of improved cocks, 3 months old chicks, or fertile eggs from different sources such as from breeder groups (fertile eggs), RMRCs (3 months old chicks) and from commercial producers or micro-enterprises (3 months old chicks). So, every year, a minimum of 10 breeder groups will be organized and each group will have 25 members. The new member of a breeder group will be provided with 25 grower horro chicken (20 female & 5 male). Afterwards, all the surplus breeding cocks from nucleus and sub-nucleus will be disseminated to smallholder farmers in base population. Once those smallholder farmers receive improved breeding cocks, they will cull their unimproved cocks of indigenous horro for slaughtering.

9. BREEDING STRUCTURES

The breeding structure of the selected scheme will be a 3-tier closed nucleus breeding scheme (Figure 2). In this scheme, the breeding stock will be kept long time at Tier-1 (DZ-ARC) for continuous genetic evaluation and selection. Afterwards, fertile eggs of selected breeding stock will be disseminated from (tier-1) to tier-2 (Bako and Ambo RCs) .

At tier-3, the organized breeder groups will take the responsibility of producing and disseminating fertile eggs to commercial producers (job creation) and smallholder farmers in base population. Those breeder farmers may use broody indigenous hens to hatch few fertile eggs for their own flock replacement.

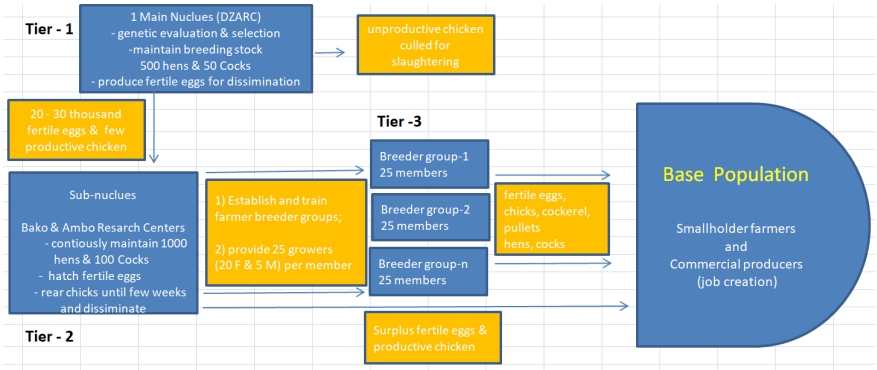

Figure 2 a 3-tier closed nucleus breeding scheme for developing, multiplication and dissemination of dual purpose horro chicken breed

So, in this selected scheme, every year, 50 cocks and 500 hens will be maintained at DZARC as breeder stock and a total of 20 to 30 thousand fertile eggs will be disseminated from this breeder stock to RMRCs. Those adult breeder stock will be kept in pens. In each pen, there will be 10 hens and 1 cock. The cocks will be used rotationally. For this, they will be transferred to a new pen to join new hens every four months, i.e. they will serve in one pen only for a single clutch period. So, a single cock can serve in three pens during its productive life time (52 weeks) in the nucleus. The RMRCs will also maintain 100 cocks and 1000 hens as breeder stock and they collect eggs from their breeder stock. Afterwards, the RMRCs will hatch all collected fertile eggs, rear the chicks until 3 months age and disseminate them to organized breeder groups after retaining few chicks for their own flock replacement. In this 3-tier closed nucleus scheme, it will be possible to reach annually above 2917 farmers with 25 young grower chicken packages. Those farmers can be organized into breeder groups to produce fertile eggs and sale the eggs to smallholder farmers in base population. The breeder groups can also sale their fertile eggs to chicken producing micro-enterprises (job creation) who will be organized from jobless youth groups. This will create very good job opportunity for rural youth groups to be engaged as commercial producer in production and marketing of young growers (3 months old). Our cost-benefit analysis of dual purpose horro chicken indicate that it is more profitable to sale live horro chicken like mature growers than selling eggs to market. The cost-benefit analysis further indicated that each beneficiary household can make an annual profit of above 24 thousand birr from the sale of eggs and mature growers (cockerels & pullets) that are produced by their 25 chicken package (Table 23).

9.1.Breeding plan for Horro chicken

This Horro chicken breeding plan is assumed to be for 9 years which is until 2030 G.C. Detailed annual breeding plan was developed for the first 4 years. The plan includes annual budgeting, selection activities, mating activities, establishment of organized poultry groups (cooperatives), number of improved Cocks/Hens generated each year, and rate of dissemination.

In the selected 3-tier closed nucleus breeding scheme: 1) DZARC will serve as nucleus/ breeding unit; 2) Bako and Ambo research centers will serve as sub-nucleus with the responsibility of maintaining some breeding stock (100 cocks & 1000 hens), hatching fertile

eggs, rearing the chicks and disseminate to breeder and other groups; 3) Breeder groups (model farmers) will maintain 20 breeder hens and continuously produce fertile eggs to be sold to smallholder farmers in base population and also to chicken micro-enterprises (organized youth groups for job creation)

Base flock represents all Horro chicken population that owned by farmers, established by producing their own breeding females, purchasing breeding females from market or other farms, and used natural mating with their own Cocks. Those flocks will be targeted for improvement through flow of gene from Nucleus to village flock. The total population of indigenous horro chicken is estimated to be 29 800 (Dana et al, 2010). Assuming a flock size of 10 chickens per household, the total horro chicken base population is managed by 2980 households. Out of the 29800 indigenous horro chickens, the number of breeding hens assumed to be 25% which is equal to 7450 hens. In this breeding program, the total number of unimproved horro breeding hens (n=7450) in the base population is considered for calculating the number of elite breeding females and males required to maintain as breeder stock at nucleus.

So, in this breeding program, the plan is to double the breeding hen population in base population by disseminating same number but improved horro hens into the base population. This means 7450 improved hens will be introduced into the base population within the first four years implementation period. This means there will be a total of 14900 breeding hens in base population (7450 improved horro hens & 7450 unimproved indigenous horro hens). Mating of all breeding hens will be made with improved horro cocks. Unimproved horro cocks will be culled step by step from base population and they will be sold for slaughtering. So, to mate those 14900 horro hens in base population, about 2980 improved breeding Cocks of horro breed are required, assuming one Cock will mate on average 5 Hens using natural mating. In order to produce 7450 improved hens and 2980 Cocks, we need to test 7842 young hens (pullets) and 3137 Young Cock (Cockerels) assuming 5% culling rate. So, the 7842 young hens and 3137 young Cocks have to be generated for test mating. For this, at least 17427 day old chicks per year required assuming 50% sex ratio and 10% culling rate. For this, close to 348 adult Hens are required at nucleus, assuming 95% adult hen survival, 50% laying rate, 3 clutches per year, 51 eggs per clutch, 5% egg loss, 95% fertility, 85% hatchability and 90 chicks survival. When 348 breeder hens are maintained at nucleus, a total of 7450 adult

hens and 7450 adult cocks are produced per year. For dissemination, the extension package of 25 chickens (20 hens and 5 cocks) per household can be applied and with this package approach, the 7450 improved hens will be enough to reach to 372 households per year. So, a total of eight production years are required to reach all the 2980 households with the 25 chicken package. From the total produced improved horro cocks (n=7450), only 2980 cocks are required per year to mate those 14900 breeding hens (7450 improved horro hens & 7450 unimproved indigenous horro hens), assuming 1 cock for 5 hens. The remaining cocks can be used to mate unimproved indigenous hens in the base population. It will be agreed in advance with farmers that once they received improved horro cocks, they will immediately cull their unimproved indigenous horro cocks for slaughtering. The number of years required to reach all the 2980 households with the 25 improved chicken package can be shortened by creating additional sub-nucleus which will maintain some breeder stock and contribute to horro breed multiplication and dissemination. For this, the Bako and Ambo research centers will be considered to maintain relatively equal number of breeding stock to that of the main nucleus (DZARC). The estimated number of adult breeder hens required to be maintained at DZARC is 348, but this number will be increased to 500 to let produce extra individuals for flock replacement and for research purpose. So the total number of breeder stock to be maintained at sub-nucleus (Bako & Ambo) will be 1000 hens and 100 cocks. In this approach, it will be possible to reach all the 2980 smallholder households with 25 improved chickens within 4 years assuming the first year will be time of preparation and constructing the necessary infrastructures in nucleus and sub-nucleus centers. From those 2980 farmers, 750 of them will be organized into 30 breeder groups within four years period and the remaining 2230 farmers will be part of the producer groups in base population. The farmers to be organized as breeder group are those model farmers with better resource and intense interest for the business as breeder group. So, in the four years period, a total of 30 breeder groups will be established. Each group will have 25 members and each member will maintain 25 adult improved chickens (5 cocks and 20 hens). These breeder farms will hatch few fertile eggs traditionally using broody hens and rear the chicks for their flock replacement and sale the majority of collected fertile eggs to commercial producers (job creation). The following breeding plan can be adopted to implement the set activities in 4 years period (Table 24).

Table 24. Breeding activity plan

Sr.n	Activity	Year 1	Year 2	Year 3	Year 4
1	Submitting final version of breeding program document	✓			
2	Conducting consultative workshops for awareness creation and incorporating stakeholder inputs	✓			
3	Allocating annual budget for main and sub-nucleus	✓	✓	✓	✓
4	Employing or assigning experts and technical assistants at NAGII, main & sub-nucleus centers for the breeding program	✓			
5	Building or renewing chicken houses and other necessary infrastructure at DZARC and sub-nucleus centers	✓			
6	Make available fully functional hatchery and feed processing plants at DZARC & RMRCs	✓			
7	Establish and implement a database system for pedigree and performance recording at the nucleus	✓			
8	Choosing 500 hens & 50 Cocks as starting genetic materials from currently existing 14th generation at DZARC	✓			
9	Contacting Bako & Ambo RC and make the necessary arrangements for horro chicken breed multiplication and dissemination plans	✓			
10	Discussion with Horro district administrative personnel, livestock extension , co-operative office, elderly and other key personnel of the community on the breeding program	✓			
11	Producing fertile eggs from breeder stock of DZARC & disseminate to RMRCs		✓	✓	✓
12	Hatching fertile eggs & rearing chicks at RMRCs		✓	✓	✓
13	Forming & training horro chicken breeder groups (model farmers)		✓	✓	✓
14	Forming & training horro chicken commercial producer groups (job creation)		✓	✓	✓
15	Disseminating growers to breeder groups and smallholders		✓	✓	✓
16	Disseminating fertile eggs to commercial producer groups		✓	✓	✓
17	Develop forage production (e.g. Alfalfa, moringa, etc) and feeding strategy		✓	✓	✓
18	Number of fertile eggs distributed from DZARC to RMRCs		20 – 30 thousand	20 – 30 thousand	20 – 30 thousand
19	Number of participating breeder groups to be formed		10	10	10
20	Number of commercial producer groups to be formed		5-10	5-10	5-10
21	Linking breeder and commercial producer groups to local and central markets		✓	✓	20 – 30 thousand
22	Total number of breeding stock to be maintained at tier-1 (DZARC)	50 Cocks & 500 Hens	50 Cocks & 500 Hens	50 Cocks & 500 Hens	50 Cocks & 500 Hens
23	Total number of breeding stock to be maintained at tier-2 (Bako and Ambo RC)		100 Cocks & 1000 Hens	100 Cocks & 1000 Hens	100 Cocks & 1000 Hens
24	Number of breeding stock maintained at tier-3 (per breeder group), i.e. each breeder group will have 25 members, each member will keep 5 cocks & 20 Hens		125 Cocks & 500 Hens	125 Cocks & 500 Hens	125 Cocks & 500 Hens
25	M & E of planned activities	✓	✓	✓	✓
26	Evaluating the overall success of the designed breeding program		✓	✓	✓

Incorporating molecular information in Horro chicken breed improvement

In the long run, a typical genetic evaluation program (Figure 3) which incorporates both quantitative genetics parameters and molecular marker information can be applied at least for traits with very low heritability and for those traits that are not directly measured on live chicken, e.g. carcass quality traits (leanness, fatness) where animals need to be slaughtered to measure those traits.

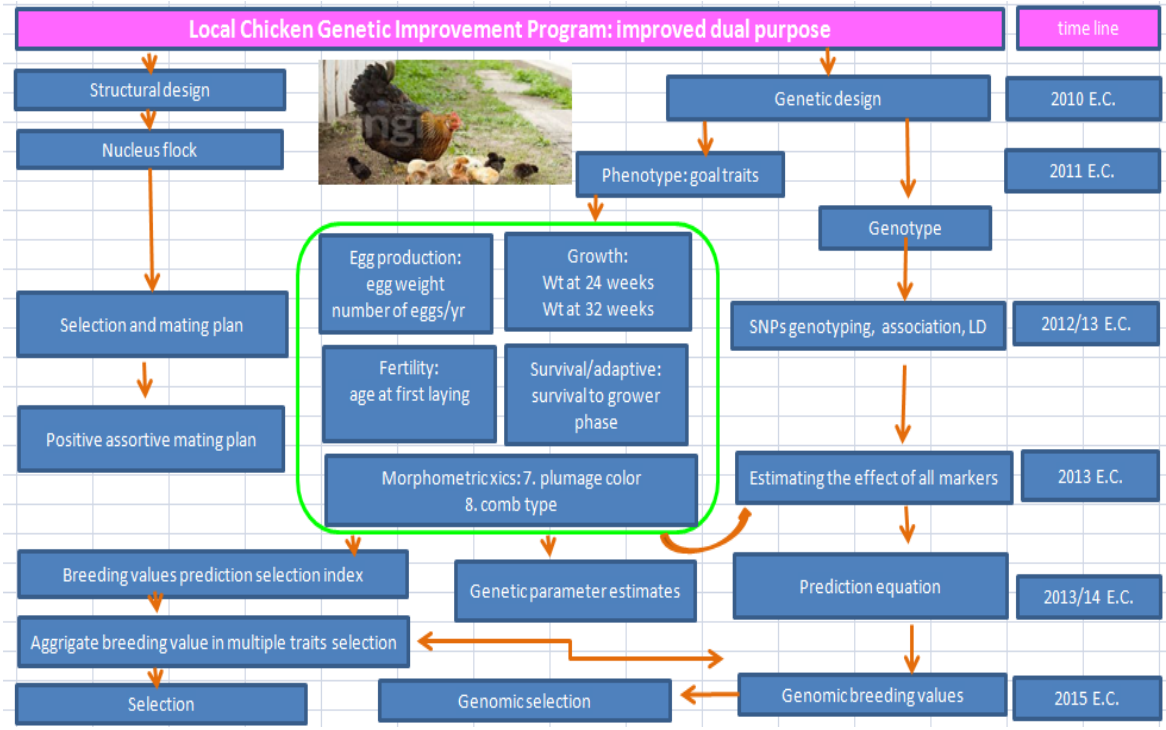

Figure 3 a typical breeding program incorporating use of molecular information for parent selection without sacrifying animals for trait measuring

10. EVALUATION AND DISSEMINATION STRATEGIES

10.1 Data Recording, management, and analysis

Sound data recording and coordinating system is a pre-requisite to make the proposed breeding program successful. Selection candidates need to have animal identification to record their individual pedigree and phenotypic performance. The following data will be recorded for each chicken for evaluation.

- Pedigree records; animal id, dam id, sire id need to be recorded for each animal. The traits for which data to be recorded are:

- Age at first egg, which refers to the number of days to the production of the first egg will be calculated from the hatching date of the hen to the production of the first egg;

- Eggs will be collected from the start of lay to the age of 45 weeks including pre-laying age of the hen;

- Body weight of the chicks will be taken at the beginning and recorded as initial weight. Then, the average body weight will be measured every 15 days using a sensitive balance by weighing chicks in each pen;

- Fertility (%) = [Number of fertile eggs/Number of total eggs set]x100;

- Hatchability (%) = [Number of chicks hatched/Number of fertile eggs set] x100;

- Chicks survivability (<24 wks) = [Chicks survived up to 24 wks / Total chicks hatched out] x 100;

- Chicks survivability (>24 wks) = [Chicks survived after 24 wks/Total chicks during 24 wks of age] x 100

10.2. Genetic evaluation

Once the proposed horro chicken breeding program is implemented, it has to be continuously evaluated. In the indigenous chicken breeding program, genetic and economic gains, inbreeding rate and reduction in genetic variance due to selection can be predicted using SelAction (Zerehdaran et al., 2009b; Bijma et al., 2001). Selection will be based on estimated breeding value for both males and females. Nucleus males and females will be evaluated based on own and relative performance on number of eggs, growth rate, age at first egg, survival rate, and egg weight. Males with highest estimated index value will be used as breeding cocks to breed dams and or sires. Hens with highest index values will also be selected to breed dam and sire. Phenotypic information on animals and their relatives from nucleus and pre-nucleus population will be collected and used to estimate breeding value for breeding goal traits using BLUP computer software. The estimated breeding values and their economic values will be used in selection index to determine total merit of individual animals. Animals with top index values will be selected from both male and female candidates to be used as parent for producing next generations.

10.3. Dissemination of genetic superiority

Genetic progress for Horro chicken is created in the nucleus, but the final aim is to improve the performance of the entire indigenous horro chicken population. Thus, the genetic improvement generatedin the nucleus has to be disseminated. Genetic material can be disseminated to the end users, through fertilized eggs, young growers, or mature hens and cocks.

In this breeding program, three models of distribution of Horro chicken genetic superiority were identified and compared, among which, a 3-tier closed nucleus breeding scheme (Figure 4) was selected as the most prominent model. In this scheme, Tier-1 will be the main nucleus (DZARC), Tier-2 will be regional M&R Centers and Tier-3 will be local breeder groups.

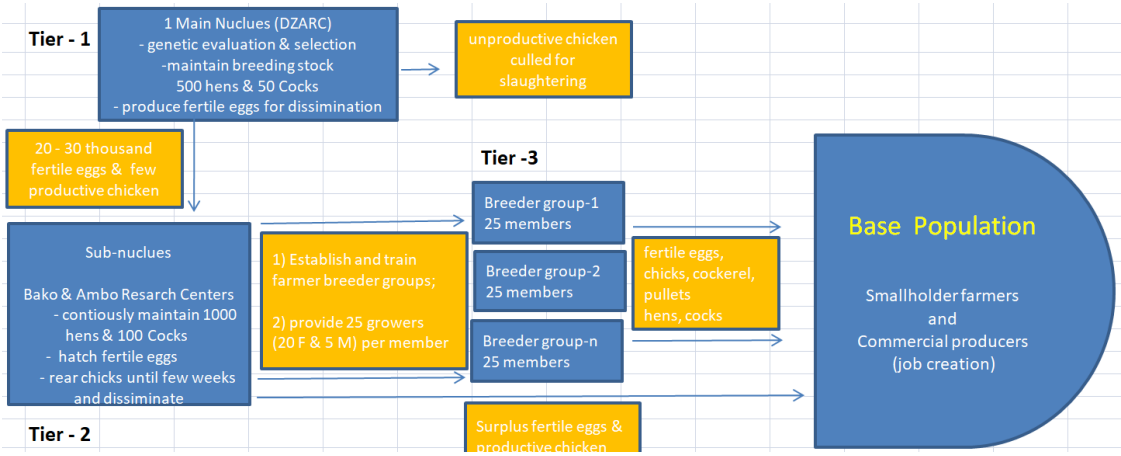

Figure 4 a 3-tier closed nucleus scheme

Based on this, the following dissemination strategy needs to be followed to make the proposed Horro chicken improvement breeding program successful:

Screening of currently existing advanced generation (G14) of Horro chicken at DZARC for establishing nucleus and sub-nucleus flocks. Currently, there are above 1000 (M&F) growers and chicks representing the 14th generation of improved Horro chicken breed at DZARC. So, they need to be screened in order to choose and maintain better producing hens (500) and cocks (50) as parental breeding stock at main nucleus (DZARC). This number of hens and Cocks will be continuously maintained at DZARC as parental breeding stock for long term breeding plan primarily targeting chicken farming communities

of Horro district but also for any other community groups of Ethiopia who are interested to be engaged in improved dual purpose horro chicken production and marketing. Those adult breeder stock will be kept in pens. In each pen there will be 10 hens and 1 cock. The cocks will be used rotationally. For this, they will be transferred to a new pen to join new hens every four months, i.e. they will stay in one pen with 10 hens only for a single clutch period. So, a single cock can serve in three pens during its productive life time (52 weeks) in the nucleus.

- Stakeholder meeting will be made with the Horro district livestock extension unit, elderly community groups, local authorities and other key stakeholders to discuss on Horro chicken breeding program agenda.

- Afterwards, farmers, youths and other Horro community groups that are interested to be engaged in Horro Chicken breeder or producer groups will be chosen and organized. Each year, a minimum of 10 groups, each with 25 members will be formed as Horro chicken breeder or 5 – 10 groups as producer groups.

- For the first few years of the project period, each year, fertile eggs of chosen hens from the main nucleus (DZARC) will be disseminated to the regional multiplication and rearing centers (Bako & Ambo RC). Those regional multiplication and rearing centers will hatch the eggs and rear the chicks until 3 monthd of age. Afterwards, they will disseminate the young growers to the organized breeder groups. Each individual in breeder group will receive a total of 25 improved grower chicken (20 F & 5M). The remaining male young growers of improved horro chicken breed will be disseminated to smallholder farmers in base population. After those farmers receive improved horro cocks, they will cull their unimproved indigenous cocks for slaughtering.

- The roles of the breeder groups will be to continuously maintain some breeder stock in semi-scavenging system with standard supplementation (formulated from locally available feed resources), and produce fertile eggs to be used for replacing their own breeder stock and sale the majority of fertile eggs in local markets (smallholder farmers and chicken producing micro-enterprises). Those breeder groups can hatch few fertile eggs

traditionally using broody indigenous hens for flock replacement. Each broody hen will be provided with 15 to 17 fertiles eggs to hatch.

- The productive life of improved horro hens and cocks at nucleus and breeder farms will be considered as 75 and 52 weeks for hens and cocks, repectively The source for breeder stock replacement at breeder farmer groups will be mainly from the hatch they will made traditionally by using broody indigenous hens.

- On the other hand, those commercial producer groups (chicken micro-enterprises) will buy fertile eggs from breeder groups and/or the regional multiplication and rearing centers (Bako & Ambo RC) and hatch the eggs using the hatchery facility of those RMRCs. Afterwards, they will raise the chiks and sale the in local markets at the age of 3 months old.

- Through time, the organized breeder groups will be very well capacitated with the necessary knowledge, skills, capital, and physical facilities (hatchery and feed processing). So, at this stage, in collaboration with NAGII and RMRCs, the organized Horro breeder groups (cooperatives) can form a big association (e.g. breeding association) so that they can independently handle horro chicken breed evaluation, selection, multiplication, dissemination, maintenance and marketing of farm products.

- In the long run, those organized breeder farms or improved family units, might be transformed into small and medium sized commercial poultry farming units, where they need to have other chicken breeds that are comparatively better producing than improved horro breed. In this case, they need to have access for highly producing breed alternatives. Although there are various meanses to avail better breeds, one possible way is to develop synthetic breed composed of improved horro breed with one or more of imported and locally adapted chicken breeds. This can be achieved by applying the following steps: i) crossing improved horro hens with cocks of imported and locally well adapted layer line-1, e.g. White Leghorn; ii) crossing hen of first filial (F1) generation with cocks of imported and locally well adapted layer line-2; iii) crossing hen of second filial (F2) generation with cocks of improved horro breed. Afterwards, some males and females individuals can be selected from F2 generation and they can be mated each other to produce third filial (F3) and advanced generations. The best individuals from advanced generations can be main-

tained as breeder stock and they can be multiplied to provide better breed for small and commercial poultry producer. However, the synthetic breeds need to be maintained only for commercial purpose in confined system to avoid mixing with the base horro chicken population.

- If there is a need to have long living synthetic broiler breed, the same crossbreeding procedure can be followed to develop synthetic broiler breed composed of improved horro breed and other two imported and locally adapted broiler breeds (e.g. Sasso).

11. ROLE AND RESPONSIBILITIES OF INSTITUTIONS

Table 25. Roles and responsibilities of institutions

Breeding interventions	Institution	Roles/responsibilities
Develop model breeding program	NAGII, MoA, EIAR & ATA	
Construction/maintenance of breeding house	NAGII	
Institutionalizing/coordinating breeding initiatives	NAGII	- Identification of chicken breeding initiatives, Identify duplication of effort - Delegate roles and responsibilities to institutions that would contribute to identified poultry breeding projects/ programs as per the structure of the NAGII
Restructuring or coordinating breeding resources	MoLF, Regional Bureaus, EIAR, RARIs,	- Pooling poultry breeding resources - Establishing National poultry improvement centers
Re-structuring ongoing genetic improvement initiatives	NAGII, Regional Bureaus, RARI, Int'l DPs,	-Coordinating & scaling up community-based poultry breeding activities/ projects - Review of central nucleus-based research projects/flocks - Evaluation, documentation, and supporting ad hoc crossbreeding activities
Capacity development	Federal/Regional Gov'ts	-Assigning technically appropriate expertise to run breeding programs, including at managerial/directorate levels
	Federal Gov'ts	-Staffing NAGGI with capable experts to lead national poultry breeding program technically
	Federal/Regional Gov'ts	-Establish and capacitate national poultry breeding centers of excellence, staffed with a critical mass of expertise

	NAGII	-Formation of advisory technical team comprising of national and international professionals to advise NAGII and national centers on poultry breeding
	Federal/Regional Gov'ts	-Training program to strengthen NAGII, national centers, poultry breeding centers
Strategy for accelerating genetic improvement	RARIs	-Identify one breed of indigenous chicken in each region to establish reference flocks for genomic selection
	RARIs, EIAR, CGIAR	Introduction of AI in poultry cross-breeding programs
PPP model for Commercialization of chicken breed technologies	Regional and national Gov'ts	- Public sector Support required
Breed conservation	IBC	
Poultry breeding as opportunity for small businesses	Research	-design Support to incorporate job/ small business opportunities in programs
	Regional and national Gov'ts	-Credit facilitation
Database system	NAGII	
Developing new indigenous chicken breeding programs	Regional Bureaus, RARIs	-Identify and prioritize breeds in each state – stakeholder Group Work

Table 26. Budget

Sr.N	Activity	Year 1	Year 2	Year 3
1	Buildings	6000000	300000	2000000
2	Plant & machinery	2000000	1000000	1000000
3	Deep litter equipment	20000	30000	30000
4	Point of lay cost	1500000	3750000	3750000
5	Establishment of breeder and producer groups	300000	300000	300000

6	Document preparation	150000	150000	150000
7	Capacity building Trainings	600000	600000	600000
8	Wage	550000	550000	550000
9	Travels- field visits (perdiem, fuel, lubricant, vehicle maintenance, etc)	900000	900000	900000
10	Workshops	500,000	500,000	500,000
11	Other miscellaneous	300,000	300,000	300,000
	Sub-total	12,820,000	8,380,000	10,080,000
	Contingency (10%)	1282000	838000	1008000
	total	14,102,000	9,218,000	11,088,000

12. Expected outputs

- A standard breeding program targeting dual purpose horro chicken breed development, multiplication, distribution and maintenance developed
- Horro chicken breeding program and data recording well organized and centrally coordinated
- A model breeding program that can be adopted to other indigenous chicken breed and ecotypes' genetic improvement and sustainable use availed
- Production and productivity performance of horro chicken enhanced by 3 to 5 folds for meat and egg as compared with the performance of unimproved indigenous flocks
- The socio-economic contributions of horro chicken to household and national income increased
- Participation of smallholder farmers, rural youth and women as well as government and non-government organizations including private companies in horro chicken breed development, multiplication, distribution and marketing enhanced
- Horro chicken value chain improved
- Access to improved dual purpose horro breed and associated package enhanced

- Traditional chicken farms transformed into improved family poultry units
- Horro chicken breeder and producer groups organized and capacitated
- Household income, asset, food and job opportunity increased
- Linkage among various actors in horro chicken value chain strengthened
- knowledge and skill on designing and implementation of standard breeding programs for indigenous chicken enhanced
- Information on improved horro chicken and its impact on livelihood of smallholder farmers and other beneficiary groups generated

13. Target groups and beneficiaries

The primary target groups and beneficiaries of this breeding program are smallholder farmers, women and youth groups in horro areas of western Oromia region in Ethiopia. Improved horro breed will reach target groups in form of fertile eggs, day old chicks, pullets, cockerels, adult hens and cocks. The breeding program will positively impact the income, asset, food and societal status of those primary target groups. Flock management training will be an important contribution to the target groups. Other beneficiaries will be technology multipliers, egg and meat consumers, researchers, extension agents, graduate fellows, and breeding companies. Due to improved breed and adopted innovations, egg and meat production will be enhanced and this will enhance products supply to households, market and industries. Knowledge to be transferred through training, seminar and workshops will enhance stakeholders' awareness on improved horro breed development, multiplication, dissemination, maintenance as well as breed production performance and socio-economic contributions. Furthermore, the breeding program will strongly support implementation of the government plan to transform traditional poultry farms into improved family poultry units.

Breeding activity plan

The following breeding plan can be adopted to implement the set activities in 4 years period.

Table 27. Breeding activity plan

Sr.n	Activity	Year 1	Year 2	Year 3	Year 4
1	Submitting final version of breeding program document	✓			
2	Conducting consultative workshops for awareness creation and incorporating stakeholder inputs	✓			
3	Allocating annual budget for main and sub-nucleus	✓	✓	✓	✓
4	Employing or assigning experts and technical assistants at NAGII, main & sub-nucleus centers for the breeding program	✓			
5	Building or renewing chicken houses and other necessary infrastructure at DZARC and sub-nucleus centers	✓			
6	Make available fully functional hatchery and feed processing plants at DZARC & RMRCs	✓			
7	Establish and implement a database system for pedigree and performance recording at the nucleus	✓			
8	Choosing 500 hens & 50 Cocks as starting genetic materials from currently existing 14th generation at DZARC	✓			
9	Contacting Bako & Ambo RC and make the necessary arrangements for horro chicken breed multiplication and dissemination plans	✓			
10	Discussion with Horro district administrative personnel, livestock extension , co-operative office, elderly and other key personnel of the community on the breeding program	✓			
11	Producing fertile eggs from breeder stock of DZARC & disseminate to RMRCs		✓	✓	✓
12	Hatching fertile eggs & rearing chicks at RMRCs		✓	✓	✓
13	Forming & training horro chicken breeder groups (model farmers)		✓	✓	✓
14	Forming & training horro chicken commercial producer groups (job creation)		✓	✓	✓
15	Disseminating growers to breeder groups and smallholders		✓	✓	✓
16	Disseminating fertile eggs to commercial producer groups		✓	✓	✓
17	Develop forage production (e.g. Alfalfa, moringa, etc) and feeding strategy		✓	✓	✓

18	Number of fertile eggs distributed from DZARC to RMRCs		20 – 30 thou-sand	20 – 30 thou-sand	20 – 30 thou-sand
19	Number of participating breeder groups to be formed		10	10	10
20	Number of commercial producer groups to be formed		5-10	5-10	5-10
21	Linking breeder and commercial producer groups to local and central markets		✓	✓	20 – 30 thou-sand
22	Total number of breeding stock to be maintained at tier-1 (DZARC)	50 Cocks & 500 Hens	50 Cocks & 500 Hens	50 Cocks & 500 Hens	50 Cocks & 500 Hens
23	Total number of breeding stock to be maintained at tier-2 (Bako and Ambo RC)		100 Cocks & 1000 Hens	100 Cocks & 1000 Hens	100 Cocks & 1000 Hens
24	Number of breeding stock maintained at tier-3 (per breeder group), i.e. each breeder group will have 25 members, each member will keep 5 cocks & 20 Hens		125 Cocks & 500 Hens	125 Cocks & 500 Hens	125 Cocks & 500 Hens
25	M & E of planned activities	✓	✓	✓	✓
26	Evaluating the overall success of the designed breeding program		✓	✓	✓

Monitoring & Evaluation: logical framework

The success of this breeding program highly depends on the designing and implementation of sound monitoring and evaluation plans. A logical framework will be used as M&E tool. So, in this breeding program the planned activities and envisaged outputs as well as indicators and targets are presented as follows (Table 28).

Table 28. Monitoring and evaluation: logical frame work

Narrative Summary	Objectively verifiable indicators	Means of verification	Important Assumptions
Goal			
1. To improve the livelihood of smallholder farmers in horro area of western Oromia by increasing their income, asset, nutrition, access to market and job opportunity through designing and implementation of participatory dual-purpose horro breeding program	1.1 Egg production per hen increased by 3 to 5 folds compared with indigenous horro chicken performance 1.2 Meat production per adult cock/hen increased by 2 to 3 folds compared with indigenous horro chicken performance 1.3. Household income increased by 15 to 30% 1.3. An increase in egg and live chicken supply from individual household to local market by 25 to 50% 1.4 Surplus egg consumption by the family increased by 20 to 30% per week 1.4. Number of beneficiaries from job creation interventions including employment of daily laborers (200 to 300)	- on-farm performance evaluation reports - chicken technology inventory assessment reports -breeding program impact assessment document -Reports from M & E committee	-Political stability in breeding program implementation sites - allocation of sufficient budget - active participation of teams implementing the breeding program and other stakeholders
Purpose			

1. Enhance horro chicken breed production and productivity to enhance income, assets, food & nutrition of small-holder	1.1 Number of farmers (1500 to 2000) who begin to use improved horro chicken breed and associated package 1.2 Number of improved horro breed technologies (fertile eggs, chicks, growers, adult hens and cocks) that are disseminated to beneficiary groups 1.3 Number of rural women and youths participated in job creation (200 to 300) 1.4. Number of organized farmers as breeder group (1.5. number of organized commercial groups	- filed observation and farm monitoring reports -breeding program impact assessment report -Quarterly and annual reports	- good understanding of the breeding program agenda by all stakeholders - dedication of breeding program implementation team and other stakeholder - good climate condition
Expected-Out put			
1.Improved horro chicken breed production & productivity	1.1. Number of introduced horro chicken breed, feed, housing, veterinary as well as capacity building interventions that improve production and productivity 1.3. increased total number of eggs collected per clutch per hen (3 to 5 fold)	- filed visit and observation -Quarterly reports - reports of M & E team	- strong community motivation to participate in the breeding program - willingness and active facilitations from local administrative staffs and community leaders -smooth procurement procedure

Logical Frame work (... Contd)

Narrative Summary	Objectively verifiable indicators	Means of verification	Important Assumptions
Expected-Out put			
2.Genetic progress achieved in goal traits	Genetic gain per year, i.e. changes in percentage of units on goal traits due to genetic improvement intervention	Reports, publication	-The planned breeding program is to be implemented accordingly
3.enhanced egg production for family nutrition	-change in number of eggs consumed by farming households (increased by 1 -2 L per day)	-reports - reports of M & E Committee - field visit and observation	-Well awareness of egg consumption for balanced nutrition - no health problem prohibiting egg consumption

			- political stability
4. Knowledge and skill improved	Number of farmers and other stakeholders trained on management of improved horro chicken breed, feed, health, and other innovations	- Quarter and Annual reports of the project - feedback from beneficiary and nearby extension personnel	- enough budget for training
5. Increased household income and asset	-Number of eggs and live chicken supplied to market -income obtained from the sale of eggs and live chicken - account opened and money saved in the bank - generated assets in terms of number of improved horro breeder stock, egg storage & hatching facilities. - other asset bought from improved horro chicken business	- monthly, quarterly, annual reports, -filed visit and observation -reports on pre and post intervention technology inventory	- good deposit making and saving culture - emphasis given for chicken as a good business - collaboration from the local administrative staffs
6. increased promotion and market access for improved horro chicken breed technologies	4.1 Number of farmers adopted one or more of improved horro chicken breed technologies (1500 – 2000) 4.2 Number of farmers trained on techniques and methods of managing introduced improved horro chicken technologies (400 to 600) 4.3 Number of linkages established with existing poultry cooperatives (5 to 10) 4.4. number of types of improved horro chicken breed technologies and farm input materials for which access to market created (5 to 10 types)	- project progress reports -quarter, annual reports - reports of M&E Committee - filed visit and observation	-Existing cooperatives are willing to link with new one organized for job creation - active collaboration from district level agricultural extension and local administrative staff - enabling financial policy

14. General flock management

14.1. Intensive management system

The on-station intensive management system of horro chicken breed at DZARC was previously reported by Dana et al. (2011). According to the author, in each generation collected eggs are artificially incubated. All hatched chicks are checked for deformity, vaccinated (against Marek's at the hatchery, Newcastle at Day 1 and 21, Gumboro at day 7, Fowl pox in week 10 and Fowl Typhoid in week 14) , wing tagged, weighed and randomly assigned into pens of concrete floor filled with bedding material. The chicks are provided ad libitum with a standard chick (0-8 weeks: 20% CP and 2950 Kcal/kg of ME), grower (8-20 weeks: 18% CP and 2750 Kcal/kg of ME) and layer (21-onwards: 16%cp and 2750 Kcal/kg of ME) diet formulated at the center. The chickens are reared in a single deep litter house until 18 weeks of age under a standard housing space, with natural lightning after 8 weeks of age. From week 18 onwards, the selected males and all females are transferred to the layer house and kept in floor pens with 1 male and 10 females per pen. Pens are fitted with trap nests to facilitate full pedigree recording. Eggs are collected from selected hens for 10-12 days and incubated in three hatches to produce the next generation.

14.2. Semi-intensive and extensive management systems

The production system revenue and expenses analysis showed that keeping dual purpose Horro chicken breed is economical only in semi-intensive and extensive systems. In semi-intensive system, improved horro chicken breed can spent some hours daily in scavenging and they need to be supplemented with a formulated feed from locally available cheap feed sources. As improved horro chicken needs more feed than unimproved ones, the formulated feed in semi-scavenging system needs to be balanced to satisfy the nutritional requirement of improved horro breed; however, the cost of formulated feed need to be below 50% of the cost incurred for feeding the chicken in intensive system. On the other hand, in extensive or free range production system, at least cocks of improved horro chicken can be provided to slowly upgrade the genetic potential of unimproved indigenous horro chicken and those flocks can be managed with grain and few other supplementations.

15. REFERENCE

Alemu, Y. and D. Tadelle, 1997. The Status of Poultry Research and Development in Ethiopia, pp: 40-60. In: Fifth National Conference of Ethiopian Society of Animal Production (ESAP), 15-17 May 1997, Addis Ababa Ethiopia.

CSA 2018/19: Statistical Abstracts. Central Statistical Agency. Addis Ababa, Ethiopia.EIAR, (2017). Ethiopian Institute of Agricultural Research. Livestock and Fisheries Research Strategies. Poultry, Fisheries, Apiculture and Sericulture, (2016 -2030). P. 286.

Emebet, M. 2015. Phenotypic and genetic characterization of indigenous chicken in Southwest Showa and Gurage Zones of Ethiopia. Ph.D. Thesis, Addis Ababa University, Ethiopia.

FAOSTAT, 2016. FAO Statistical Year Book. Food and Agriculture Organization of the United Nations Regional Office for Africa, Accra.

Gondwe TN, Wollny CBA (2007). Local chicken production system in Malawi: Household, flock structure, dynamics, management and health. Trop Anim Health Prod. 39: 103–113.

Halima, H. M. 2007. Phenotypic and genetic characterization of indigenous chicken population in Northwest Ethiopia. PhD Thesis submitted to the faculty of natural and agricultural sciences, department of animal, wild life and grassland sciences, University of the free state Bloemfontein, South Africa, pp:95.

Jansen T, Glatz PC, Miao ZH (2009). A survey of village poultry production in the Solomon Islands. Trop Anim Health Prod. 41: 1363–1370.

Kondombo SR (2005). Improvement of village chicken production in a mixed (chicken-ram) farming system in Burkina Faso. PhD Thesis, Wageningen Institute of Animal Sciences, Animal Nutrition Group, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands, 1-200.

Livestock Development Technology Roadmap (Ministry of Science and Technology), Bishoftu, August 2016.

Livestock Master Plan, Roadmaps for Growth and Transformation, Developed by the LMP team for the Ministry of Agriculture, Livestock Resources Development Sector, March 2014.

M, Masika PJ (2009). Ethno-veterinary control of parasites, management and role of village chicken in rural households of Centane district in the Eastern Cape, South Africa. Trop Anim Health Prod. 41: 1685–1693.

National poultry breeding strategy ministry of Agriculture (MoA), 2019: https://www.moa.gov.et

National Poultry Research Strategy of Fifteen Years (2016-2030), Ethiopian Institute of Agricultural research (EIAR), December 2016.

Nigussie, D. 2011. Breeding programs for indigenous chicken in Ethiopia, Analysis of diversity in production systems and chicken population, PhD Thesis submitted in fulfilment of the requirements for the degree of doctor at wageningen University, The Netherlands:148.

Ngeno, K.Breeding program for indigenous chicken in Kenya. Analysis of diversity inindigenous chicken populations.154 pages.PhD thesis, Wageningen University, Wageningen, NL (2015) With references, with summaries in English and Dutch. ISBN 978-94-6257-277-5

Olwande PO, Ogara WO, Okuthe SO, Muchemi G, Okoth E, Odindo MO, Adhiambo RF (2009). Assessing the productivity of indigenous chicken in an extensive management system in southern Nyanza, Kenya. Trop Anim Health Prod. DOI 10.1007/s11250-009-9418-4.

Ralph L. Roothaert , Ssebina Ssalongo & Jjuuko Fulgensio (2011) The Rakai chicken model: an approach that has improved fortunes for Ugandan farmers, International Journal of Agricultural Sustainability, 9:1, 222-231, DOI: 10.3763/ijas.2010.0563

Tadelle, D. and B. Ogle, 2001. Village poultry production in central highlands of Ethiopia. Tropical Animal Health and Production Journal, 33(6): 521-537.

Tadelle, D., 1996. Studies on village poultry production systems in the central highlands of Ethiopia. M.Sc. Thesis, Swedish University of Agricultural Sciences.

Teketel Forsido, 1986. Studies on the meat production potential of some local strains of checkens in Ethiopis, PhD. Thesis submitted to Geissen, Germany, J.L. University of Geissen, pp:186.

USAID (2010). Audit of USAID/Ethiopia's Agricultural Sector Productivity Activities. Audit Report No 4-663-10-003-P.

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