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# Alternative-Based Breeding Schemes for Designing Genetic Improvement of Indigenous Goats in the Western Lowlands of Ethiopia

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**ABSTRACT**

Without well-designed national animal genetic improvement schemes, achieving and monitoring genetic gains is difficult. Therefore, the objective of the present study was to compare designs of alternative-based breeding schemes for genetic improvement of western lowland Arab goats. In the current study, four schemes for the village-based were designed and evaluated for sustainable and operationally feasible breeding programs. The results indicated that monetary genetic gains for the central nucleus scheme were higher than the village-based schemes. Among the central nucleus-based, scheme-5 gave the highest genetic progress in monetary terms (31.27/doe/year). Scheme-1 produced high genetic improvement and was the most efficient of all other village schemes. The trait of more significant genetic gain for the six-month weight (6MW) was predicted from central nucleus scheme-5, and scheme-1 was the highest among the village schemes. The results showed that the central nucleus-based plans were fairly superior to the village-based breeding scheme in terms of annual genetic response and profit. However, the central scheme was not appreciable under smallholder breeders' management practices since it requires high investments. Given this limitation, a cooperative village scheme linked with a central nucleus scheme is the best option for fast genetic gains and profits. Nonetheless, to upgrade the entire Arab goat flocks which are kept under small-scale farmers' conditions, scheme-1 could be used as an alternative option.

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## Introduction

Identification, characterization, and understanding of local breeds as well as associated contexts of their development and utilization is the first step in making well-informed decisions on breed improvement interventions. Designing a suitable breeding scheme for smallholder livestock production systems has remained a challenge in most developing countries. Until lately, livestock breed improvement in Ethiopia has adopted exclusively the conventional hierarchical breeding schemes [1]. Despite empirical data on the description of the so-called "economically important" traits of the breeds, conventional approaches have so far failed to capture a holistic picture of breeding in the context of traditional systems. In developing countries with low-input production systems, breeding schemes, and structures are uncommon and livestock keepers have usually limited access to get improved breeding stock and rely mainly on their traditional breeding practices. In addition, the lack of infrastructure for breed improvement and the scarcity of logistics are other factors to establish such breeding schemes [2]. To overcome these challenges, village-based breeding schemes have been suggested and designed for low-input production systems [3].

Hence, in the past few years community-based breeding program (CBBP) which is a process that needs a bottom-up approach, has appeared as a promising come up to in the tropics. Such a program that has a more participatory approach to identifying and understanding the native animal genetic resources is flourishing in various parts of Ethiopia [1,2]. Therefore, using CBBP efforts have been made to plan breeding schemes to transform the conventional nucleus breeding approach into a sustainable participatory breeding scheme [3].

The lack of efficient, sustainable breeding programs for indigenous breeds in developing country like Ethiopia is one reason that such breeds lose their competitive benefit due to changing production systems and external conditions. The Arab goat which is distributed predominantly in the Benishangul-Gumz region in the western lowlands of Ethiopia plays significant roles for the communities. Although the breed is kept for multiple purposes with traditional breeding practices of the community, comprehensive information is scanty to design a community-based breeding program to improve the breed. This requires suitable breeding strategies and optimal breeding programs, which consider the existing farmer organizations, common networks, and available support services. Hence, the present study was conducted with the objective of evaluating alternative breeding schemes for optimizing Arab goat genetic improvement program in western lowlands of Ethiopia.

## Materials and Methods

### Study Area

This study was conducted in Assosa and Kumruk districts of Western zone of Benishangul-Gumuz National Regional State. Assosa district is located between 10° 02.922' N latitude and 34° 33.868' E longitude. It is characterized by diverse topography with an altitudinal range of 580-1544 m.a.s.l. Mono-modal rainfall pattern during April-September with average annual rainfall of 1316 mm, and temperature of 11 to 30°C with the hottest months of March and May are the feature of the district [4]. According to Benishangul-Gumuz Regional Statistical Data information, (the total livestock population in the district is consisted of 29,927 cattle, 4,778 sheep, 25,917goats, 74 mules, 5,171 donkeys, and 33,177 poultry [5].

Kumruk district is located between a latitude and longitude of 10°32′ N latitude and 34°17′ E Longitude. The altitudes range from 500 to 1200 m a.s.l. The temperatures range from 25 to 33oC and the hottest months are March and May. The district is characterized by mono-modal rainfall with a mean annual rainfall range of 800-to1200 mm Assosa Agricultural Research Center [6]. The total livestock population of the district is estimated 123, 479, 26,387, and 6,078 for cattle, sheep, goats, and poultry, respectively [5].

### Description of Breeding Practice and Production System

The traditional goat husbandry and breeding practices of the community, production system, production objective, infrastructure, and marketing systems of the area were studied using participatory approaches [7, 8]. Goat keeping is a major livestock enterprise for the community and the Tropical Livestock Unit (TLU) of goats was greater than any other livestock types [8]. Natural pasture, crop residue, and hay were the main feed possessions in both dry and wet seasons. The average number of goats per household was 11 during the study periods [8]. The major feed sources include free grazing on pastureland, which is far from the homestead, and crop residues that are in short supply. During the dry season, animals suffer from a shortage of feed and are travailed to the adjacent forest and riverbanks where they can get sufficient pasture and water. Uncontrolled goat breeding practice was the main feature of the community [8]. The most frequently reported reason for keeping goat was cash income generation and save followed by milk and meat production for home use [8]. Goat milk contributes significantly to the diet of the children in the area. Castration of male goats after being used for mating service was ordinary practice in these areas [8].

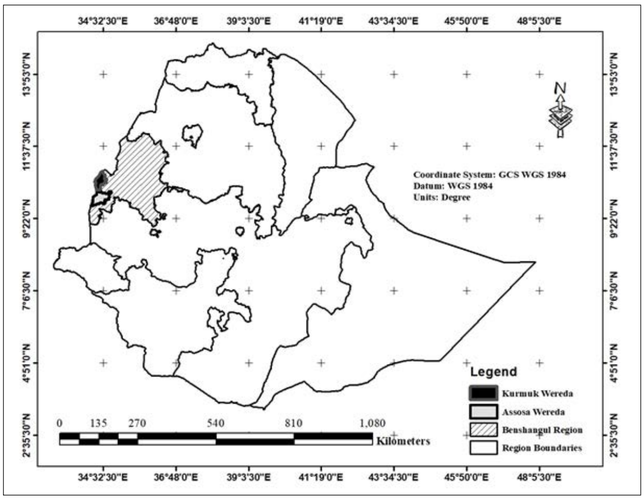


**Figure 1:** Geographical locations of research sites (Assosa and Kurmuk districts)

### Breeding Objective and Selection Criteria

The identification of farmers trait preferences were studied using participatory trait preference ranking the production system studies, own flock ranking conjoint experiments and developing deterministic bio-economic models [7, 9, 10,11].

The overall weight rank farmer traits preference identified for this study using three participatory approaches (trait preference ranking, own flock ranking, and conjoint experiment) were size, multiple births, growth, mothering ability, kid survival, and milk yield (Table 1). In this study, bio-economic models were also constructed on a Microsoft Excel spreadsheet to derive economic values of the following traits (six-month weight (SMW), litter size (LTS), pre-weaning kid survival rate (PWS), post-weaning average daily gain (PoADG), and daily milk yield (DMY). The economic values of each trait were used from the bio-economic evaluation results of the Arab goat. Breeding objective trait parameters were generated based on the results of three participatory approaches and a bio-economic model. In this study, an attempt was made to establish relationships among the objective traits and only economically relevant traits that directly influence Arab goat-keeping farmers' profitability/income were considered (Table 3).

**Table 1:Doe traits preferences from different studies and their weighted ranks**

| Traits | TPR (a) | OWR (b) | CE (c ) | WR (Y) |
|---|---|---|---|---|
| Body size | 0.119 (3) | 0.29(1) | 48.43 (1) | 1.67 (1) |
| Kid growth | 0.176 (2) | 0.29(1) | 2.62 (5) | 2.67 (2) |
| Twining | 0.224 (1) | 0.21 (2) | 2.10 (6) | 3.00 (3) |
| Kid survival | 0.090 (6) | 0.20 (3) | - | 4.50 (5) |
| KI | 0.110 (4) | 0.20 (3) | 5.27 (4) | 3.67 (4) |
| Milk yield | 0.081 (7) | 0.09 (4) | | 5.50 (6) |

TPR, trait preference ranking; OR, own ranking; CE, conjoint experiment; WR, weighted rank.

**Selection of Population Structure and Groups for A Breeding Program**

The Arab goat population in the two districts was estimated to be 52, 304, of which 46.82% were breeding does. Therefore, a total of 24, 489 breeding does in the two districts were used in the village selection scheme. A total of 4 selection groups for each one-tier central nucleus and village-based breeding scheme were defined to designate the selection pathways. A selection group is defined by both, the type of parents (one sex) passing genes and the type of offspring receiving their genes. First and second selection groups are bucks born in nucleus to breed bucks (bucks to breed bucks, BB>BB) and does (bucks to breed does, BB>DB) for nucleus. Third and fourth selection groups are does born in nucleus to breed bucks (does to breed bucks, DB>BB) and does (does to breed does, DB>DD) for nucleus. A selection of breeding stock was based on individual phenotypic values for village flocks where as selection of breeding stock for central nucleus was based on Best Linear Unbiased Prediction (BLUP) of estimated breeding values. Finally, two-step selection procedures were envisaged for young bucks in village flocks. The selection procedure was based on a selection index, including the performance of the dam (dam's kid-rearing record) and own growth performance six month weights of the young male goats, not like the selection of female breeding stock in the central nucleus.

**Description of Alternative Designs of Breeding Schemes**

The schemes were designed based on the practical situation on the ground. These include the actual population of Arab goats in the two main districts, the feasible size (number of does) of the cooperative breeding groups that can be organized (which varied from 500 to 200 does) depending on several factors including the proximity of villagers, sharing of common resources such as grazing land which are necessary for organizing controlled breeding within the cooperative breeding group, and the central nucleus size which can be established by the Assosa research center or ranch (which varied in the model from 5% of the population which is 12224 to 1% which is 242 does).

In this study, two main schemes (a cooperative village breeding and a central nucleus scheme) and four sub-schemes for the village program and two sub-schemes for the central nucleus program were designed and evaluated as optimal breeding programs. Each scheme varied in the nucleus breeding units in percentage (1 and 5) of the population, number of nuclei, flock size, and selection method. The two scenario schemes identified were village-based (schemes 1, 2, 3, and 4) and conventional central nucleus-based schemes (schemes 5 and 6) were used as presented in Table 1. Details of the six breeding schemes are given below.

**Scheme 1:** (dispersed village nuclei with 5% of the total doe population and a village nucleus size of 500). The scheme involves cooperation among farmers in a village. Scheme-1 was planned to scale up genetic improvement from single village activities to the entire population of the district goats kept by small-scale farmers. Genetic gain is generated in the nucleus flocks and spread using males (bucks that do not qualify to be used in the nucleus flocks) to the base flocks through purchase, loan and communal use. The size of one breeding unit and village nuclei were designed to be 5% of the base population and 500 does (one village nucleus size), respectively. Selection of candidates based on mass selection (phenotype). Each year the inferior buck of the nucleus is replaced by a new best-performing young buck whereas the base male progeny are castrated or else revolve fund, and nucleus male progeny are performance tested. It was planned to keep superior males during the mating season to allow community members to take their best females for mating. Genetic gain generation and dissemination occur within this single breeding unit. A total of three village nuclei, 500 does in each nucleus unit was modeled in this alternative scheme.

**Scheme-2:** (dispersed village nuclei breeding scheme with 5% breeding unit and a village nucleus size of 200). Sceme-2is similar to scheme-1 but in scheme2, the size of one village nuclei was modeled to be 200 flocks with seven village nuclei. It simulates a selection program addressing the whole goat populations in the districts. Candidates are selected using mass selection and farmers' assessment. Generation of genetic gain and distribution occur inside the single breeding unit.

**Scheme-3:** (dispersed village nuclei breeding program with 1% breeding unit and a village nucleus size of 500).Same as schemes 1 and 2, but this scheme was designed with a breeding unit of one percent of the total base population. In this scheme, the size of one village nuclei was modeled to be 500 breeding does. The cooperative village required one nucleus that can be organized based on the proximity and exclusion of other flocks outside the cooperative villages. Dissemination and genetic generation take place within this on its own breeding unit.

**Scheme-4:** (dispersed village nuclei breeding scheme with 1% breeding unit and a village nucleus size of 200). This alternative breeding scheme was a one-tier cooperative village breeding scheme. Similar to scheme 3 but in scheme 4, the size of one breeding unit was designed to be 1% of the base population with a total of two village nuclei. Genetic generation and dissemination arise in this single breeding unit.

**Scheme-5:** (conventional central nucleus scheme with five % nucleus size): It was modeled with a nucleus size of 5% of the whole population of does. This scheme involves a single tier of multipliers for single community flocks. This does away with the intermediate sire multiplier flock stage and requires full cooperation between participating farmers and the elite nucleus breeders. Assosa Agriculture research institution can manage the central nucleus breeding flock. The number of does (480) comprises five percent of the total control base population and 19 breeding bucks. There would be 10 nucleus flocks and each does will be divided into ten flocks of 48 does/flocks. The top 5% of the bucks will be selected for the nucleus flocks as the future sires. The top-performing females will then be bred to the top (5%) bucks for use inside the central nucleus flock. The top second sires will be distributed to smallholder farmers flocks who participating in the program.

**Scheme-6:** (Central nucleus scheme with 1% of nucleus size): similar to scheme-5, but it was modeled with 1% nucleus size. The central nucleus breeding program consists of 240 breeding does and 10 bucks. There will be 10 nuclei and each nucleus consists of 24 does/flocks. One percent of the top bucks will be selected to be the future sires for the nucleus flocks. The second top sires will be disseminated to flocks of smallholder farmers joining in the program.

**Input Parameters for the Breeding Program**

In Table 2, all input parameters of Arab goat for modeling (running ZPLAN) are presented. The population parameters were the number of breeding does, mating ratios, age at first kidding, number of kids per doe per kidding, productive lifetime, and survival rates. The salaries of animal breeding experts for genetic evaluation, technical field assistants, and village coordinators, as well as costs for maintaining nucleus flocks, data processing facilities, and supplies and communications are include as fixed costs. The variable costs include costs for animal identification and recording traits. Expenses related to data recording (enumerator, animal identification, stationery, and weighing balance) costs were calculated for all schemes. Costs for data analysis (animal breeding expert and electronic data processing) were calculated for conventional breeding schemes because candidates are selected using breeding values unlike village schemes (mass selection and farmers' assessment). However, data processing expertise and related costs were not included for the cooperative village. The investment period considered was ten years, using three percent and five percent of interest rates for costs and returns, respectively.

**Table 2: Proportion of input parameters for simulation of an alternative breeding plan for Arab goat**

| Parameters | Cooperative village Schemes | | | | Central nucleus schemes | |
|---|---|---|---|---|---|---|
| | Scheme-1 | Scheme-2 | Scheme-3 | Scheme-4 | Scheme-5 | Scheme-6 |
| Population parameters | | | | | | |
| The proportion of the population in the Production unit | 0.95 | 0.95 | 0.99 | 0.99 | 0.95 | 0.99 |
| Population size | 23264 | 23264 | 24244 | 24244 | | |
| The proportion of the village nucleus | 0.05 | 0.05 | 0.01 | 0.01 | | |
| The proportion of the central nucleus | | | | | 0.05 | 0.01 |
| Nucleus flock size (number of does) | 500 | 200 | 500 | 200 | 200 | 500 |
| Number of village nuclei | 3.0 | 7.0 | 1.0 | 2.0 | - | - |
| Biological parameters: | | | | | | |
| Lifetime use (years) of bucks in the nucleus | - | - | | | 2.0 | 2.0 |
| Breeding bucks use in villages | 2.33 | 2.33 | 2.33 | 2.33 | 2.5 | 2.5 |
| Does used in the central nucleus | | | | | 6 | 6 |
| Does used in villages | 7.0 | 7.0 | 7.0 | 7.0 | 7 | 7 |
| Mating ratio (F:M)-village | 30 | 30 | 30 | 30 | 35 | 35 |
| Mating ratio(F:M)--central nucleus | | | | | 25 | 25 |
| Conception rate-central nucleus | | | | | 0.91 | 0.91 |
| Conception rate-villages | 0.90 | 0.90 | 0.90 | 0.90 | | |
| Kidding interval (years) | 0.73 | 0.73 | 0.73 | 0.73 | 0.66 | 0.66 |
| | 1.50 | 1.50 | 1.50 | | 0. 90 | 0. 90 |
| | 1.50 | 1.50 | 1.50 | | 1.00 | |
| The mean number of kids per litter (litter size) | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 | 1.44 |
| Survival of bucks-villages | 0.90 | 0.90 | 0.90 | 0.90 | | |
| Survival of bucks-central nucleus | | | | | 0.95 | 0.95 |
| Survival of does-villages | 0.89 | 0.89 | 0.89 | 0.89 | 0.90 | 0.90 |
| Survival of does-central | | | | | 0.90 | 0.90 |
| Kid weaning rate -village | 0.90 | 0.90 | 0.90 | 0.90 | | |
| Kid weaning rate-central nucleus | | | | | 0.93 | 0.93 |
| Suitability for breeding [(a)] | 0.90 | 0.90 | | | 0.90 | |
| Cost parameters | | | | | | |
| Fixed costs/doe(Birr) | 36.55 | 91.38 | 36.55 | 91.38 | 115.56 | 36.55 |
| Variable costs/doe (Birr) | 6.86 | 6.86 | 6.86 | 6.86 | 6.86 | 6.86 |

(a) Proportion of proven selection candidates physically suitable for breeding.

**Genetic and Phenotypic Parameters**

The phenotypic standard deviations and genetic and phenotypic correlations are showed in Table 3. The genetic and phenotypic correlations and heritability estimates for Arab goats are not available. Therefore the estimates of the breeding objective traits of the breed were obtained from previous published research studies on indigenous and exotic of small ruminants [12]. Nevertheless, the phenotypic standard deviations of traits were calculated from data collected from the Arab goat monitoring study [13].

Table 3, Phenotypic standard deviations (σp), phenotypic correlation (on the diagonal), genotypic (below the diagonal) heritability of the traits (along diagonal), and economic values of the traits used in the simulated breeding schemes for Western Lowland Arab goat .

| Breeding objective traits | $\sigma_p$ | SMW | LTS | PWS |
|---|---|---|---|---|
| SMW (Kg) | 2.661 | 0.40 | 0.71 | 0.73 |
| LTS (day) | 0.490 | 0.86 | 0.16 | 0.98 |
| PWS (day) | 0.290 | 0.28 | 0.02 | 0.12 |

$\sigma_p$, phenotypic standard deviation; SMW, six month weight; LTS, litter size; PWS, Pre weaning survival rate (proportion of kids survive or weaned).

**Statistical Analysis**

The computer program, ZPLAN version 2008, was used to simulate and compare the different alternative breeding schemes [14]. The deterministic software uses gene flow methods and selection index procedures to simulate breeding programs. Based on genetic, biological and economic parameters, the computer program calculates genetic gain for the aggregate breeding value, the annual response for each trait and the profit per female animal due to selection. Profit is calculated as a difference between returns and costs.

**Results**

Table 4 provides expected annual genetic gains of the individual breeding objective traits from the different alternative breeding schemes. The results of this study indicated that annual genetic gains of the breeding objective traits were higher under central nucleus-based breeding schemes when compared to village-based breeding scheme. Among central nucleus-based schemes, scheme-5 gave higher genetic progress. From village-based schemes, scheme-1 was the highest genetic gain followed by scheme 3. Hence, village-based scheme 1 which involves a breeding unit at 5% selection proportion with a flock size of 500 does using a total of three village nuclei was effectively performed in creating genetic gain.

The higher annual genetic gain in six-month weight (SMT) was obtained from the central breeding scheme whereas under cooperative village breeding scheme the trait was lower. The results of predicted annual genetic gains year-1 for SMW and LTS per doe were higher in central nucleus schemes than village-based schemes (Table 3). The genetic gains for PWS were similar in schemes 1 and 3 and schemes 2 and 4 whereas genetic gains for PWS of central schemes were different and high in scheme 5.

**Table 4: Predicted genetic gains of the breeding objective traits under different breeding schemes**

| Traits | Dispersed village-based scheme | | | Central nucleus scheme | | |
|---|---|---|---|---|---|---|
| | Scheme 1 | Scheme 2 | Scheme 3 | Scheme 4 | Scheme 5 | Scheme 6 |
| Breeding objectives | 8.587 | 8.470 | 8.530 | 8.384 | 31.271 | 30.948 |
| SMW (kg) | 0.1995 | 0.1968 | 0.1982 | 0.1948 | 0.7267 | 0.7192 |
| LTS (%) | 0.0022 | 0.0021 | 0.0021 | 0.0021 | 0.0068 | 0.0067 |
| PWS (%) | 0.0017 | 0.0016 | 0.0017 | 0.0016 | 0.0045 | 0.0044 |

The genetic gains in the breeding objective (monetary genetic gain) were calculated as the sum of the products of the genetic gains in the component traits (SMW, six months weight; LTS, litter size, PWS, pre-weaning survival rate) and their corresponding economic values.

As in any other activity, a breeding program presents costs for its implementation and it is necessary to monitor them so that there are economic benefits from the program. Table 5 describes overall discounted return, returns per trait and profit per doe and per year. From the two scheme groups (central and village) the highest annual return on investment in the breeding program was predicted from scheme-5 of central nucleus-based schemes and scheme-1 of village breeding schemes. The annual costs per doe in the whole population were higher for the central nucleus-based scheme compared to the village-based scheme. Among village-based schemes, the annual costs were higher for schemes 1 and 2 which were designed for a 5% selection proportion than those designed with a 1% selection proportion in schemes 3 and 4. Within a central nucleus-based group, a higher annual cost was observed on scheme 5 than 6.

The relation profitability of all breeding schemes in the village-based group followed a similar pattern as their returns, except for scheme-3 and 4. The latter scheme was less profitable than the former despite its higher cost. From the village and central breeding nucleus groups, the latter was more profitable than the former. Within the village-based schemes, scheme-1 was the highest profitable design of its contemporaries. In central-based schemes, scheme-6 was more profitable than scheme-5.

**Table 5: Returns, costs, and profits per doe and per year in the alternative breeding schemes (Birr)**

| Traits | Dispersed village-based scheme | | | Central nucleus scheme | | |
|---|---|---|---|---|---|---|
| | Scheme 1 | Scheme 2 | Scheme 3 | Scheme 4 | Scheme 5 | Scheme 6 |
| Return/doe/year | 43.17 | 42.65 | 30.74 | 30.17 | 177.18 | 135.25 |
| Cost/doe/year | 2.05 | 4.61 | 0.41 | 0.92 | 114.72 | 40.91 |
| Fixed costs per doe | 1.71 | 4.27 | 0.34 | 0.85 | 107.97 | 34.15 |
| Variable costs | 0.34 | 0.34 | 0.07 | 0.07 | 6.759 | 6.76 |
| Profit/doe/year | 41.13 | 38.05 | 30.33 | 29.25 | 62.46 | 94.35 |

The total returns with the breeding objective of genetic improvement in SMT, LTS, and PWS traits were superior in central nucleus-based schemes than in village breeding schemes (Table 6). The comparison among the component traits for the predefined breeding objective revealed that genetic improvement in six month weight was the only contributor to higher returns on investment in all six schemes. Higher genetic improvements in all traits were found in village nucleus scheme-1 and central nucleus scheme-5. Return per year for SMW, twining rate, and PWS traits ranges from 30.45-29.89, 0.13–0.21, and 0.15-0.24, respectively in village-based schemes while in central nucleus schemes, it ranges from 133.96-175.37, 0.66-0.92, and 0.63-0.89, respectively.

**Table 6: Returns per year (Birr) obtained from selection in Arab goats using six alternative breeding schemes**

| Traits | Dispersed village-based scheme | | | Central nucleus scheme | | |
|---|---|---|---|---|---|---|
| | Scheme 1 | Scheme 2 | Scheme 3 | Scheme 4 | Scheme 5 | Scheme 6 |
| SMW (kg) | 42.72 | 42.20 | 30.45 | 29.89 | 175.37 | 133.96 |
| LTS | 0.21 | 0.21 | 0.13 | 0.13 | 0.92 | 0.66 |
| PWS | 0.24 | 0.24 | 0.15 | 0.15 | 0.89 | 0.63 |

**Discussion**

The objective of each breeding scheme was maximization of genetic gain per generation and per year. The monetary genetic gains of the central nucleus-based scheme in the breeding objective were higher than village-based schemes. The highest prediction of genetic gain from central nucleus-based compared with the village-schemes in the current study may be due to inaccurate genetic evaluation and inefficient utilization selection method and population size differences. Study by, described that genetic progress could be slow under village programs because of inaccurate genetic evaluation due to difficulties in implementing advanced selection tools such as best linear unbiased prediction (BLUP) selection and inefficient utilization of selected animals due to uncontrolled village breeding practices [3]. A study by in Ethiopia explained that the variation in genetic gain between central and village nucleus schemes is attributed to the accessibility of communications, logistics, and technical know-how and support [15].

The present study results show that cooperative village-scheme-1 was the most economically impact in genetic gain and flock genetic improvement than all other village schemes due to higher selection intensity through increment of the breeding unit and flock size in comparison to other schemes in the same group. As the size of the population increase (both breeding unit and flock size as in the case of village scheme 1) in a flock the selection differential would be increased and this brought high selection intensity and increased rate of genetic gain per generation and per year, also showed that as the number of candidates becomes lower, selection intensity would be reduced and as a consequence, genetic improvement would be inefficient and genetic progress could be lower. Similarly study by, also explained that the high within-breed genetic variation in indigenous livestock populations indicates a high expected response to selection [15-18].

Rapid genetic progress and profit from scheme 1 were also envisaged all the way through improved breeding practice with other matching interventions (enhanced health and feeding management) and assimilating/extent-out a breeding program intervention (integrating/linking a village-based nucleus scheme to a central nucleus scheme). The study by, recommended that a central nucleus breeding scheme linked to disperse village breeding schemes would be a viable alternative to conquer the operational difficulties of the central based nucleus breeding program [15]. In addition, an earlier study by, also suggested that nucleus breeding units could be included with on-farm performance assessment, and as a result, immediate, faster, and additional effective genetic progress can be realized through the selection of superior foundation animals [19]. The integration increases the births of more kids at a certain kidding period of the year, induces faster growth, and reduces mortality and acute shortage of breeding bucks, which enable the program to achieve faster genetic progress and higher selection intensity.

The predicted highest annual genetic gain in SMW was acquired from a conventional central breeding scheme might be due to the implementation of advanced selection tools and efficient utilization of selected animals through controlled mating and higher selection intensity from large flock sizes. However, the lowest annual genetic gains in SMW traits were lower for village-based schemes, since candidates' animals are selected based on phenotype through mass selection and farmers' trait preferences which may not include all traits. also described that a central nucleus scheme with a selection of animals using breeding values of their traits had a benefit over a cooperative village-based scheme [3, 20, 16]. The genetic gain of 6-month weight in village and nucleus schemes (0.1948 to 0.7267) in the current study was upper than the range for Abergelle (0.174 to 0.249 kg) and Woyto-Guji (0.188 to 0.270 kg) goats, Gumz sheep (0.154 to 0.336 kg) [12,17]. However, it is lower than 0.7590 to 0.6747 kg for the Begit goat and 0.871 to 0.8724 kg for the Abergele goat [16,21]. Higher genetic improvements in all traits were found in village nucleus scheme-1 and central nucleus scheme-5 because higher returns benefited from the selection of higher profits per doe per year (Birr).

Very low progress in genetic gains of LTS and PWS traits in the present study indicates their immediate improvement could be achieved through improving management and hence, did not adversely affect the efficiency of genetic progress among cooperative village breeding programs and central-based nucleus schemes. Thus, comparable results were predicted from all alternatives. Lower genetic gain in reproductive traits is attributed to their low heritability and genetic associations with growth traits [22]. Similarly also noted that the annual genetic gain for litter size and number of kids weaned were small indicating sufficient management measures should be element of the breeding activity [12]. This indicated that some traits preferred by farmers in dispersed village breeding practices are compatible with modern animal selection methods or selection criteria [3]. Conversely, substantial genetic progress in body weight could be attained using farmers' subjective selection criteria of linear body measurements due to the high genetic association among body weights and linear size traits [23].

The comparative profitability of all schemes followed a similar pattern as their returns, except for scheme-3 and scheme-4, but scheme-4 was found to be low profitable than Scheme-3 regardless of its higher cost. This implies that as flock size increases high selection differentials could be achieved and profitability maximize through the genetic gain of the flock. Hence, village-based schemes with breeding units of 5% of the total doe population (scheme-1 and scheme-2) were a better option breeding situation to schemes in the cooperative village farmer breeding programs. Increasing the breeding unit from 1 to 5% in the village nuclei (Scheme-1 and 2) increased the returns by 45.57% and 4.38% over scheme-3 and 45.80% and 5.06% greater than scheme-4. This is due to the higher total returns on investment in the breeding program in scheme-1 and Scheme- 2 than in scheme-3 and Scheme 4. Among the central-based schemes, scheme-6 was more profitable than scheme-5, due to the high discounted costs for maintenance (107.965Birr// does/year) in scheme-5 than scheme-6 (34.148Birr//does/year).

In this study, central nucleus-based schemes were highly profitable designs as compared to village-based schemes. also reported that pertain higher selection intensity would result from the higher genetic gain in one hand and higher discounted incomes on the other hand [15,17]. Studies indicated that the selection of animals from their breeding value estimated using an advanced selection tool could be better than a selection of animals from their phenotypic performance under the village-based scheme [12, 16]. This is because the phenotypic performance of animals could have resulted from environmental and genetic effects and the former (environment) causes of variation may overlap the genetic performance and biased selection of animals from their phenotypic performance. The study by noted that a central nucleus-based scheme with selection on breeding values had an advantage over a village-based nucleus scheme where selection of candidates' was on the bases of phenotypes [15].

The result of the present study indicated that relatively few differences in return per trait were observed among dispersed village-based nucleus schemes (schemes 1-4) and central nucleus schemes (scheme-5 and 6). However, the total returns for the component traits of breeding objective genetic improvement in SMW, LTS, and PWS were higher in the central nucleus-breeding schemes. This is due to a good environment and management in the central nucleus-based schemes than village schemes which could increase animal efficiency for low heritable traits. Similarly, the study by reported higher discounted returns for all breeding objective traits in the conventional central breeding scheme and than in a cooperative village scheme [17].

## Conclusions

The result of the current study showed that the breeding schemes, central nucleus scheme were superior genetic gain and economic impacts in all breeding objectives traits compared to village-based schemes. Nonetheless, the central breeding scheme was not appreciable under smallholder breeders' management practices due to the requirement of large central nucleus flocks and inputs. In the current comparison of the various breeding scenarios showed that from central scheme (scheme 5: 5% selection proportion) and village schemes (scheme 1: a breeding unit of 5% and a village nucleus size of 500) are the most efficient response schemes that need to be optimized. From the finding of this study, two options of breeding programs could be suggested for implementation in small-scale farmers of the study area by considering anticipates available recourses, infrastructure, logistics, socio-economic, and decisions of the community. Thus, for the improvement of Arab goat populations under small-scale farmers' conditions, scheme-1 could be suggested to start a feasible community-based breeding program. On the other hand, scheme 1 (linking with conventional scheme 5) could be an alternative option to attain faster and more effective genetic progress through the selection of superior foundation animals under a low-input smallholder farming system. This suggestion of implementing various options of breeding schemes would be sustainable provide that farmers could practice performance data record keeping, selection, management, and use in village herd producers.

## Authors' Contributions

Conceptualization, Befikadu Z.; Methodology, Yosef T. and Shibabaw B.; Software, Befikadu Z. and Yosef T.; Validation: Yosef T. Investigation, Befikadu Z.; Formal analysis, Befikadu Z,. Yosef T. and Shibabaw B.; Investigation, Befikadu Z. and Yosef T.; Resources, Befikadu Z.;Data curation, Befikadu Z.; Writing-original draft preparation, Befikadu Z. and Yosef T.; Writing-review & editing: Befikadu Z., Yosef T. and Shibabaw B.; Visuilization, Befikadu Z. and Shibabaw B.; Project administration, Befikadu Z.

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## Conflicts of Interests

The authors declare no conflict of interest. The sponsors also had no role in the design, execution, interpretation, or writing of the study [18-23].

## References

1. Gizaw S, Getachew T, Edea Z, Mirkena T, Duguma G, et al. (2013) Characterization of indigenous breeding strategies of the sheep farming communities of Ethiopia: A basis for designing community-based breeding programs presented. at International Agriculture Research for Dry Land 2: 4.
2. Mueller JP, Rischkowsky B, Aynalem H, Philipsson J, Mwai O, et al. (2015) Community-based livestock breeding programs: essentials and examples. Journal of Animal Breeding Gent 132: 155-168.
3. Gizaw S, Getachew T, Haile A, Dessie T (2011) Congruence between the selection of breeding rams based on breeding values for production traits and farmers ram choice criteria. J Animal Sciences 7: 995-1001.
4. Assefa T, Samson L, Samuel D (2015) Prevalence of Donkey Trypanosomosis in Assosa District, Benishangul Gumuz Regional State, Northwest Ethiopia. Acta Parasitologica Globalis 6: 147-153.
5. BGRSD (2011) Benishangul-Gumuz Regional Statistical Data/ Information / reported from Benishangul-Gumuz Regional State Bureau of Finance and Economic Development, Three-year Strategic Plan (2003/04-2005/06).
6. AsARC (2011) Results of farming system survey Benshangul-Gumuz Regional State. Ethiopian Institute of Agricultural Research; Assosa Agricultural Research Center Assosa, Ethiopia.
7. Bryan KO (2014) Getting Started with conjoint analysis:

strategies for product design and pricing research.
8. Befikadu Z, Mengistu U, Yosef T, Solomon G (2020) Arab Goat Husbandry, Breeding Practices and Marketing Systems in Western Lowland of Ethiopia. East Africa Journal of Vet, Animal Sciences 4: 27-40.
9. Duguma G, Mirkena T, Haile A, Okeyo AM, Tibbo M, et al. (2011) Identification of smallholder farmers and pastoralists' preferences for sheep breeding traits: choice model approach. animal, Cambridge University 5: 1984-1992.
10. Mirkena T, Duguma G, Willam A, Wurzinger M, Haile A, et al. (2012) Community-based alternative breeding plans for indigenous sheep breeds in four agroecological zones of Ethiopia. Journal of Animal Breeding Gent 129: 244-253.
11. Lopes FB, Borjas AR, Silva MC, Faco O, Lobo RN, et al. (2012) Breeding goals and selection criteria for intensive and semi-intensive dairy goat system in Brazil. SRR 106: 110-117.
12. Jembere T (2016) Genetic parameters, productivity indices, and breeding plans for designing Community-based goat breeding programs in Ethiopia. Ph.D., Ddissertation, Haramaya University, Ethiopia.
13. Befikadu Z, Mengistu U, Yosef T, Arvind C (2022) Solomon G. Productive and Reproductive Performances of Arab Goats in the Western Lowlands of Ethiopia. Journal of L Sciences 10: 21-32.
14. Willam A, Nitter G, Bartenchlager H, Karras K, Niebel E, et al. (2008) ZPLAN manual for a PC program to optimize livestock selection schemes. Manual Version 2008 for Source Code "z10.for". Institute of Animal Production in the Tropics and Subtropics.' University Hohenheim, Stuttgart, Germany.
15. Gizaw S, Rischkowsky B, Valle-Zarate A, Haile A, Van Arendonk JAM, Okeyo AM, Dessie T (2014a) Breeding programs for smallholder sheep farming systems. Evaluation of alternative designs of breeding schemes. Journal of Animal Breeding Genetics 131: 341-349.
16. Abraham H, Gizaw S, Urge M (2018) Designing Sustainable Breeding Program for Begait Goat in Western Tigray, Northern Ethiopia. Dissertation, Ph.D., Haramaya University, Ethiopia.
17. Dagnew Y, Urge M, Tadesse Y, Gizaw S (2018) Comparative Performance Evaluation of Gumz, Rutana and Rutana-Gumz Sheep and Designing of Conservation Based Breeding Program in North Western Lowlands of Amhara, Ethiopia. Dissertation, Ph.D, Haranmaya University, Ethiopia.
18. Gizaw S, Van Arendonk JA, Komen H, Windig J, Hanotte O (2007) Population structure, genetic variation and morphological diversity in indigenous sheep of Ethiopia. Journal of Animal Gentics 38: 621-628.
19. Peters KJ (1989) Trends in on-farm performance testing of small ruminants in sub-Saharan Africa. In: Wilson R T and Azeb Melaku (eds), African small ruminant research and development. Proceedings of a conference held at Bamenda, Cameroon, 18-25, January, ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia 1989: 439-469.
20. Gizaw S, Getachew T, Goshme S, Valle-Zárate A, van Arendonk JAM, et al. (2014) The efficiency of selection for body weight in a cooperative village breeding program of Menz sheep under a smallholder farming system. Journal of Animal Breeding and Genetics 8: 1249-1254.
21. Solomon A (2014) Design of community-based breeding programs for two indigenous goat breeds of Ethiopia dissertation, Ph.D., Vienna, Austria University, Austria.
22. Safari E, Fogarty NM, Gilmour AR (2005) A review of genetic parameter estimates for wool, growth, meat, and reproduction traits in sheep. Journal of Livestock production 92: 271-289.
23. Afolayan RA, Pitchford WS, Deland MPB, Mckiernan WA (2007) Breed variation and genetic parameters for growth and body development in diverse beef cattle genotypes. Journal of Animal Sciences 1: 13-20.

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