ICARDA
Science for resilient livelihoods in dry areas

Guidelines for setting up community-based small ruminants breeding programs

Second edition

Aynalem Haile[1], Maria Wurzinger[2], Joaquín Mueller[3], Tadele Mirkena[4], Gemeda Duguma[5], Mourad Rekik[1], Joram Mwacharo[1], Okeyo Mwai[6], Johann Sölkner[2] and Barbara Rischkowsky[1]

[1]*International Center for Agricultural Research in the Dry Areas (ICARDA)*
[2]*BOKU University*
[3]*National Institute for Agricultural Technology (INTA)*
[4]*Food and Agriculture Organization of the United Nations (FAO)*
[5]*Wollega University*
[6]*International Livestock Research Institute (ILRI)*

CGIAR RESEARCH PROGRAM ON Livestock and Fish

ILRI INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

GUIDELINES

ISBN: 978-9291275212

Keywords: community-based breeding; guidelines; sheep; Ethiopia

Manuals & Guidelines
ICARDA's Manuals & Guidelines series taps the Center's expertise to provide comprehensive advice and strategies that researchers can adopt to enhance agricultural productivity and overcome critical challenges affecting rural communities in the non-tropical dry areas.
Suggested citation

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Address
Dalia Building, Second Floor, Bashir El Kasser St, Verdun, Beirut, Lebanon 1108-2010.
www.icarda.org

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Acknowledgments

The first edition of the guidelines is an output of the Austrian Development Agency-funded community-based sheep breeding project implemented in four locations representing four breeds and diverse production systems. The project is a collaborative project between the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI), the University of Natural Resources and Life Sciences (BOKU) and the National Agricultural Research Systems in Ethiopia. This edition is an output of CRP Livestock and Fish, CRP Livestock and IFAD funded project on small ruminant value chain development. We thank the staff of the research centers of Abergelle, Areka, Bako, Bonga, Debre Berhan, Mekele, Sekota and Worer for their support in implementation of the breeding programs. The target-community members are acknowledged for cooperation during the whole phase of design and implementation of the breeding programs.

Reviewed by: Jan Philipson and Paul Boettcher

International Center for Agricultural Research in the Dry Areas (ICARDA)
Dalia Building 2nd Floor
Bashir El Kassar Street, Verdun
Beirut, Lebanon 1108-2010
Tel.: + 961 1 843472/813303
Fax: + 961 1 804071/01-843473Fax: (963-21) 2213490
E-mail: ICARDA-Beirut@cgiar.org
Website: www.icarda.org

Citation: Haile A., Wurzinger M., Mueller J., Mirkena T., Duguma G., Rekik M., Mwacharo J., Mwai O., Sölkner J. and Rischkowsky B. 2018. *Guidelines for Setting Up community-based small ruminants breeding programs in Ethiopia.* Beirut, Lebanon: ICARDA.

Executive Summary

Guidelines for setting up community-based small ruminants breeding programs

These guidelines are designed for all those involved in planning and implementing sheep and goat breeding activities with resource-poor farmers in developing countries. This includes research centers, non-governmental organizations (NGOs), farmers' associations and livestock development projects and government extension officials.

About community-based small ruminants breeding programs

The guidelines address generic directions on designing and implementing community-based breeding. Community-based breeding programs are one way to genetically improve livestock in developing countries (Mueller et al. 2015). This new approach has been tested in a few places with promising results (e.g. with sheep and goat in Ethiopia, dairy goats in Mexico, llamas and alpacas in Bolivia and Peru, sheep in Argentina). The guidelines draw primarily on practical experiences from implementing community-based sheep and goat breeding programs in various agro-ecological zones in Ethiopia. They provide guidance for the continuation and out-scaling of the breeding program in Ethiopia and for planning similar programs elsewhere.

The breeding programs in Ethiopia have achieved important outcomes/impacts. For example, the program covers 3,200 households in more than 40 villages with more than 18,000 people directly benefiting from the scheme. There is increased productivity (more births, better growth and reduced mortality), increased income from sheep production and increased mutton consumption. Additionally, the cooperatives have been able to build capital for buying rams/bucks and other investments, building on the initial revolving funds supported by the project (for example, Bonga cooperative has capital of around USD60,000).

The objectives of these guidelines are to:

- describe the prerequisites and context in which community-based breeding programs can be successfully implemented;
- explain how communities can be best engaged to get actively and sufficiently involved in all the critical stages of the program (i.e. defining breeding goals and making decisions on the best implementation options and plans);
- take the user through the main steps of the design and implementation process leading to operational breeding programs and dissemination of improved genetics;
- propose appropriate local institutional arrangements within the communities' capacity to effectively manage performance recording, selection and delivery of improved genetics; and
- suggest a system for monitoring and evaluating progress and the impact of the breeding program during and after the project.

The guidelines have five parts, including:

1. General background information.
2. A user guide that informs readers on what to expect and how the guidelines should be used. It also outlines the purpose and objectives of the publication, target groups, conditions under which the guidelines should be used, structure of the guidelines and practical aspects on use of the guidelines.
3. Implementation modalities, describing the core of breeding programs, including the selection of breeds and communities, characterization of target sites and breeds, definition of breeding objectives, assessment of alternative breeding plans, the development of adequate breeding structures and the dissemination of improved genetics.
4. Issues related to enabling environments for the success of breeding programs, which details how to achieve these and includes the roles of different actors that can play a part in the program design and implementation.
5. Monitoring and evaluation for the community-based breeding programs, which include parameters, indicators and how and when to monitor the program.

While based on experiences in Ethiopia, these guidelines propose generic approaches to community-based breeding for resource-poor small ruminant keepers. As community-based breeding is a new approach, the guidelines will be refined and updated as we record and accumulate experiences in community-based breeding and our tools improve.

The team welcomes inputs and perspectives from interested readers.

Contact: a.haile@cgiar.org

1 Introduction

Genetic improvement of livestock is often viewed as a complex process, requiring technical and organizational sophistication. In Europe, animal breeding has been traditionally supported by the state where large national breeding programs have been implemented. Currently, these programs are mostly run and financed by farmer cooperatives and include data recording and processing, and the evaluation of the best candidates for optimal breeding.

In developing countries, the necessary infrastructure to carry out such programs is largely unavailable, so past attempts to replicate developed-country approaches have been met with little success. Centralized breeding schemes entirely managed and controlled by governments—with minimal, if any, participation by farmers—were developed and implemented through a nucleus breeding unit run from a central station. These centralized schemes were usually run by a governmental organization attempting to undertake all or part of the complex processes and breeding strategy roles (i.e. data recording, genetic evaluation, selection, distribution of genetically improved animals and feedback to farmers). Although well intended, these centralized schemes failed to sustainably provide the desired genetic improvements (continuous provision of a sufficient number and quality of improved breeding males to smallholders) and also failed to engage the participation of the end-users in the process. Another alternative widely followed by many developing countries or individuals was to import improved commercial breeds in the form of live animals, semen, or embryos. These were crossbred with indigenous and "less productive" breeds to improve the population; however, in most cases, this was undertaken without pre-testing of the appropriateness (suitability and adaptability) of the breeds and the resultant offspring to local production systems or conditions. Where indiscriminate crossbreeding with the local populations has been practiced, genetic erosion of the adapted indigenous populations and breeds has occurred.

A new approach gaining global interest is a community-based breeding program (CBBP). Programs that adopt this strategy take into account farmers' needs, views, decisions and active participation, from inception through implementation, and their success is based upon proper consideration of farmers' breeding objectives, infrastructure, participation and ownership (Sölkner et al. 1998; Wurzinger et al. 2011 and Mueller et al. 2015). Designing a community-based breeding program is much more comprehensive than simply applying genetic theories to achieve increased productivity. Instead, its success combines infrastructure, community development and the opportunity for improved farmer livelihoods by creating integrated processes for productive breeding of adapted animals and the markets for their products.

Cognizant of this, the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI) and the University of Natural Resources and Life Sciences (BOKU), in partnership with the Ethiopian National Agricultural Research System, have designed and implemented community-based sheep and goat breeding programs in Ethiopia. Ethiopia was selected as a case study because sheep and goats play an important role in the livelihoods of resource-poor farmers/pastoralists. The current level of productivity of the indigenous Ethiopian sheep and goat breeds under the smallholder production systems is low (Tibbo 2006). The average annual off-take rate and carcass weight per slaughtered animal for the years 2000–2007 were estimated at 32.5 percent and 10.1 kg, respectively, the lowest even among sub-Saharan African countries (FAO 2009). In parallel, the demand for sheep and goat products has increased due to a growing human population, urbanization and demand from Gulf States. There is, therefore, an urgent need to improve productivity in order to raise smallholders' incomes and meet the demands of the growing human population. Furthermore, recent assessments of the views of farmers as well as research and development views in the highlands of Ethiopia have shown that genetic improvement should receive similar priority to feeding and health issues (Edea 2008 and Getachew et al. 2010). Therefore, an integrated approach that considers genetics, nutrition, health, input supply and services, and markets is necessary.

The first edition of these guidelines was based on the experiences gained from the research project entitled, "Designing community-based breeding strategies for indigenous sheep breeds of smallholders in Ethiopia." The project was funded by the Austrian Development Agency and operated in four regions representing different agro-ecologies—at different altitudes defined by meters above sea level (MASL)—that are the habitats of four indigenous sheep breeds: Afar, Bonga, Horro and Menz (Table 1). The project was implemented with the full participation of farmers and pastoralists, and by July 2011 when the project ended, about 500 households (120–125 households per breed) owning about 8,000 sheep were enrolled in the project. This second edition is based on lessons learnt from implementation of sheep and goat CBBPs in different parts of Ethiopia through different programs and projects including: CRP Livestock and Fish, CRP Livestock, a SIDA-funded ILRI goat project, IFAD funded project on small ruminant value chain development and a SARI sheep and goat CBBP project, among others. This edition has two sub-sections which were not included in the earlier version consisting of the use of genomic tools in CBBPs and the dissemination of improved genetics from CBBPs. Additionally, the edition provides a more comprehensive discussion about complementary services needed to strengthen and sustain CBBPs.

Table 1. Characteristics of the four sites

Breed	Habitat	Production system	Major use
Afar	Hot to warm arid plains (565–1542 MASL)	Pastoral/agro-pastoral	Milk, meat
Bonga	Wet, humid (1070–3323 MASL)	Mixed crop–livestock	Meat
Horro	Wet, humid (1600–2800 MASL)	Mixed crop–livestock	Meat
Menz	Tepid, cool highland (1466–3563 MASL)	Sheep–barley	Meat, wool

Source: Authors' notes

Note: MASL=meters above sea level.

The guidelines consist of the key requirements of, and implementation modalities for, community-based small ruminant breeding in low-input systems.

2 User Guidance

2.1 Purpose and objectives of the guidelines

The guidelines are intended to assist users with planning and implementing community-based breeding programs for resource-poor sheep and goat farmers. They draw heavily on practical experiences from implementing community-based sheep and goat breeding program in different agro-ecological zones in Ethiopia, provide guidance for continuing and outscaling the breeding program in Ethiopia and for planning similar programs elsewhere.

More specifically the objectives of the guidelines are to:

- describe the prerequisites and context in which CBBPs can be successfully implemented;
- explain how participating communities can be best engaged to get actively and sufficiently involved in all the critical stages of the program (i.e. defining of breeding goals and deciding on the best implementation of options and plans);
- take the user through the main steps in the design and implementation process leading to operational breeding programs and dissemination of improved genetics;
- propose appropriate local institutional arrangements within a community's capacity to effectively manage performance recording, selection and delivery of improved genetics; and
- suggest a system for monitoring and evaluating progress and the impact of the breeding program during and after the project.

2.2 Target groups

The guidelines are intended for use by all persons and organizations interested and involved in planning and implementing breed development activities, in particular research institutions, non-governmental organizations (NGOs), private institutions (e.g. farmers' associations and livestock development projects) and government officials. In the case of the Ethiopian sheep and goat breeding programs, the target group for the guidelines include livestock keepers, national and regional research institutions, the extension system, universities, NGOs and policy makers. As the guidelines target a diverse group of actors, a knowledge of animal genetic and breeding principles is advantageous but not essential for using them.

2.3 Conditions under which the guidelines should be used

The guidelines are designed for users that wish to develop breeding programs in situations where:

- a developed infrastructure for animal genetic improvement under smallholder production systems is not in place, thus precluding direct adaptation of approaches from more developed sources;
- systematic processes for identifying and delivering genetically superior breeding stock from the local populations are lacking; and
- national research and development organizations have limited experience and a limited number of qualified staff.

Although most of the elements described here are applicable beyond the local Ethiopian scope—and hence can be easily adjusted to specific cultural, social, economic, or ecological conditions and similar production systems—the guidelines specifically address the situation of resource-poor sheep and goat keepers in Ethiopia. They describe the steps necessary to develop and implement a straight breeding program but are also applicable to organized crossbreeding programs in local communities.

The guidelines can be used in connection with the guidelines provided in "Breeding Strategies for Sustainable Management of Animal Genetic Resources," which were developed and tested by FAO (2010). Once national stakeholders have completed the decision-making process described in the FAO guidelines and prioritized local breeds for breed improvement programs, the guidelines presented here can help to plan and implement breeding strategies with farmer/pastoralist communities.

2.4 Structure of the guidelines

The main part of the guidelines consists of three sections:

- Implementation of the program and dissemination of improved genetics (Section 3)
- Creating an enabling environment for a CBBP (Section 4)
- Monitoring and evaluation of the breeding program (Section 5).

Section 3 covers the four most important steps—the core of a breeding program—to implement a CBBP:

1. Identify the target site and target group.
2. Develop a breeding plan by defining goals and selection criteria and assessing alternative breeding plans.
3. Build adequate breeding structures.
4. Disseminate improved genetics.

Section 4 explains the support required from different institutions to initiate, implement and sustain a breeding program in the long term. It also proposes complementary activities and tasks to enhance breeding program environments.

Section 5 describes and discusses the monitoring and evaluation needed to continuously assess project progress and its final success impact. This section also maps out and describes the various stakeholders throughout the process.

2.5 Using the guidelines

Developing any livestock breeding program requires the teamwork of a number of actors at the community, regional and national levels, each with different expertise and institutional backgrounds. The guidelines are intended to provide a practical and technical roadmap for participating teams and team members, including insight on whether taking the decision for community-based breeding is even an option (or the appropriate option) under the prevailing conditions.
The guidelines are presented in sections arranged in a logical sequence to help users to follow an implementation sequence. However, as outlined in Section 4, genetic improvement is only one component of population breed improvement and development. Strategies aimed at improving nutrition, marketing, health, housing and the welfare of the animals, as well as other related services, have to be taken into consideration when developing a breeding program.

Although the guidelines outline the necessary requirements and the implementation process, they also point out and discuss limitations. Embarking on the development of a breeding program, no matter whether community-based or centralized, is not simple and should therefore not be taken lightly. For a breeding program to be successful and sustainable, the long-term commitment of all stakeholders is crucial as success and tangible impact will only be achievable after several generations and many years of consistent collaboration among key actors.

3. Implementation Guidelines

3.1 Selecting target breeds and communities

3.1.1 Selection of breeds

When initiating and implementing CBBPs it is important to pick the right breeds, populations and locations to work with. There are a number of criteria to follow in selecting target breeds and communities. The criteria below should be considered when selecting breeds:

- The breeds should be among the most populous in the country with a wide area coverage so interventions can have far-reaching impact
- Breeds should be kept by resource-poor farmers/ pastoralists
- The breeds are genetically diverse as evidenced by phenotypic and potentially molecular characteristics
- The breeds in question have potential for genetic improvement
- Research/development centers with relevant expertise and interests are available within reasonable reach of the communities who keep those breeds
- Reasonably good background information is available on relevant breeds and production systems, so that planned and future research and development work has an extant foundation
- The areas selected are relatively easily accessible

3.1.2 Selection of community

Selection of the right community has been recognized as key to the success of community-based programs. Some essential factors to consider in selecting target communities for a CBBP include:

A. External factors

1. Market access, including distance to markets, transportation of products and quality of roads. This is also critical as the market is the major driving force for improvement and development projects.
2. Potential negative or positive impacts by other projects. For example, irrigation might result in more cropping and less livestock activities. A crossbreeding program could jeopardize the long-term breeding programs as farmers could see short-term impacts that cause them to abandon or disregard agreed-upon breeding plans.
3. Synergies with other projects. It is important to be aware of the possible involvement of other stakeholders in concurrent projects and allow room for their participation. For example, a development program could actually enhance the environment for achieving project goals.
4. Government support. Although this factor generally affects a whole sector and not a specific community, it is important to consider local developments being carried out in accordance to government policies and priorities. For example, if abattoirs and feed-producing plants are in existence or in development in a region where a CBBP is under consideration. The availability of good extension services to support CBBPs is also crucial.
5. Support from NGOs.
6. Availability of inputs and services (public vs private): existing or potential for development. These include forage seeds, feeds (roughage and concentrates), veterinary drugs, veterinary services, drug vendors, extension systems (technical advice) and market information systems.

B. Community-related factors

1. Willingness/interest of the community to participate in the program.
2. Key species should be a priority. A substantial portion of income should be generated from targeted livestock species. Set a minimum percentage for selection in relation to the importance of the target species at the national level.
3. The community should have a sufficiently large (combined) and equitably distributed sheep/goat flock (> 500 ewes/does). Situations where one farmer has 400 ewes/does and a few farmers have 10 ewes/does each is inadvisable.
4. Existence of communal/shared resources or institutional arrangements. For example, common grazing land or watering points and/or common use of breeding rams, herding or marketing facilities is ideal. Such arrangements indicate that some common facilities that require collective action already exist. The existing institutional setup can therefore be used as a starting point for developing institutional structures for the breeding program.
5. Presence of community leaders (elders) and champion farmers/ pastoralists who are important to social and traditional structures in the region. They should be involved as community-level facilitators to work

closely with the project's team. It is critical to identify such persons as early as possible with the help of farmers/pastoralists and also extension workers, researchers and NGOs that have previously worked in the area or are still working in the area. Religious leaders could also play important roles.

Suggested steps to follow for selecting the communities

1. Consult with extension representatives, researchers working in the area, former livestock specialists who know the area, NGOs and development project staff. It is useful to build an inventory of stakeholders and a map of actors, both of which include roles and responsibilities. Let these resource persons suggest potential or candidate communities to visit.
2. Visit the communities, if possible accompanied by people who have already developed trust within those communities and provided that they agree with your goals.
3. Organize a participatory workshop—this is an important key step. The beneficiary community as well as key stakeholders in the public sector (extensions, researchers, cooperatives, microfinance and administration) and private sectors (NGOs, traders, brokers, butchers, export abattoirs, feed suppliers and drug vendors) should be carefully identified for participation. Gender balance must also be considered. Such workshops should be organized when the community is not occupied by farm activities and facilitated by someone who understands the culture and language of the community.
4. Document the whole process, a task preferably undertaken by a communications expert.

3.2 Characterization of target sites and breeds

3.2.1 Description of the production system

Assuming that some broad information on the production system is already available from secondary sources, the characterization of production systems for the purpose of the breeding program should concentrate on these additional issues:

- Importance and function of livestock in the system and use of livestock products
- Economic evaluation of production (costs and returns from sales)
- Current breeding practices (management of males and females, herd structure, gene flows, including exchange and/or acquisition of new breeding animals)
- Marketing channels and opportunities for marketing animals and animal products
- Institutional settings that affect breeding and animal management, including marketing (decision mechanisms within the community)

This information should be collected by standard methods such as the Rapid Rural Appraisal (RRA) methodology and farm monitoring, with active participation from farmers, who can provide answers to "what" questions, followed by workshops with focus groups to provide answers to "why" and "how" questions. This will help design more accurate surveys and validate information collected at household level.

3.2.2 Breed characterization

Populations of livestock species in developing regions are traditionally recognized as distinct types by ethnic group or geographical location, from which they often derive their names. Preliminary identification of breeds or populations involves phenotypic characterization of distinct populations using a combination of stratified and purposive sampling strategies. Qualitative and quantitative descriptions, including morphometric measurements of animals, are collected through farm-level surveys to identify and describe the representative samples of animals from targeted populations, breeds or breed groups. For this purpose, a comprehensive list of animal descriptors was developed by FAO (2012) and Ayalew and Rowlands (2004).

Phenotypic characterization

Qualitative and quantitative variables to be observed and recorded include:

- Phenotype, including qualitative variables such as coat color, fiber type, face profile, presence of horn and tail type, and quantitative variables including body weight, withers height, body length and heart girth;
- Phenotypic performance characteristics, such as body weight at birth, at weaning and six months, adult weights and daily milk yield at onset or peak lactation, as well as lactation length; and
- Flock/herd-level reproductive performance data (e.g. ewe/doe fertility, lambing/kidding rates, prolificacy and pre-weaning survival rates).

Means for each quantitative measurement are calculated to describe each population sampled. Related indigenous knowledge systems can also be collected at this stage.

Genomic characterization and the potential for application of genomic tools in CBBPs

Although the use of genomics and genomics tools have been applied in dairy, poultry and pig breeding programs in the developed world, such is yet to be undertaken in CBBPs. These guidelines explore the potential for the application of genomics and genomic tools in CBBP. The application of genomics and its associated tools is most often done in genetic characterization to understand the genetic profile of an individual, populations and breeds. Genetic markers used in this type of analysis include biochemical (protein) polymorphisms, micro-/minisatellite markers, restriction fragment length polymorphisms (RFLPs), mitochondrial DNA and Y-chromosome specific markers. In recent times, SNP genotyping chips/microarrays and full genome sequencing have become the markers of choice because of their better resolution. Prior to establishing a CBBP, when written pedigree records are unavailable and random mating and communal use of resources is the norm, genetic characterization can provide an objective assessment and understanding of the genetic relationships and differences within and between the target populations. Such a study was carried out by Gizaw et al. (2007), whose findings were used to select some of the target populations for the implementation of the CBBP in Ethiopia.

Once the CBBP is established and running, in cases where accurate pedigree records are either incomplete or unavailable for any number of reasons—whether stolen matings from non-particpating flocks due to communal use of resources, farmer buy-ins from non-participating flocks and/or socio-cultural exchanges—genetic markers can be used to provide accurate estimates of co-ancestry and genomic relationship matrices can allow better sire verification and assignment to breeding flocks. This has implications for the CBBP because the accuracy and completeness of pedigrees is important in increasing the rate of genetic gain. A CBBP can also serve as a valuable resource for research under farmer conditions. For instance, when coupled with genomic tools, genomic data can provide information on rare variants segregating within and between populations and investigate the genetic architecture underpinning quantitative and qualitative traits through selection sweep analysis, genome-wide association mapping (GWAS) and QTL-mapping.

Comparative genomics analysis using animals from non-participating flocks and those participating in the CBBP can be used to assess changes at the genome level arising as a result of the implementation of the breeding program in subsequent generations of breeding.

Genomic selection (GS) (Meuwissen et al. 2001) has been incorporated into the selection schemes of dairy cattle to produce highly accurate genomic breeding values (GEBVs) for young bulls (Hayes et al. 2009; Spelman et al. 2013) and pig companies have started using it in their elite populations (Hidalgo et al. 2015; Tusell et al. 2016). The performance of GS has been evaluated in autochthonous Spanish beef cattle populations (Mouresan et al. 2017), indicating its potential for use in local populations. CBBP can provide the framework to test the potential application for GS for indigenous livestock under small holder farming systems in developing countries. This can be trialed under the open (Figures 2 and 3), closed (Figures 2 and 3) and dispersed nucleus (Figure 4) frameworks. In the case of closed and open nucleus frameworks, the nucleus acts as the reference population, while for the dispersed nucleus, the test station can act as the reference population. Phenotypic recording and genotyping/genome sequencing is done for all the individuals making up the reference population. This provides the training datasets that can be used to build statistical models and prediction equations to estimate SNP/marker effects viz:

$$Yi = \mu + X1ib1 + X2ib2 + \ldots\ldots + X5000ib5000 + ei;$$

Where Y_i = phenotypic record of animal i; μ = average phenotypic performance; X_{1i} = random polygenic effect (genotype) of animal i for SNP/marker 1 with values 0, 1, 2 (homozygous, heterozygous, alternate homozygous); b_1 = random effect for a paternal (k = 1) or maternal (k = 2) haplotype at locus j of animal i; e_i = residual.

No recording and genotyping/sequencing is necessary in the base populations. Once the prediction equations have been developed, selection candidates which are either offspring from the reference populations or from the base populations (selected by farmers based on their own criteria) are genotyped. The genotype data from the selection candidates is then combined with the estimated SNP/marker effects to derive their genomic breeding values (GEBV). For instance, the estimate of genomic breeding value of selection candidate j can be derived as:

$$GEBVj = X1jx1 + X2jx2 + X3jx3 + \ldots\ldots\ldots\ldots\ldots X5000jx5000$$

Where: X_{1j} = the genotype of animal j for SNP/marker 1; x_1 = the estimate of the effect of SNP/marker 1.

Modifications to this two-step approach as originally applied by Meuwissen et al. (2001) have been proposed since. Habier et al. (2007) proposed an adaptation of the standard mixed-model equations to incorporate genomic information through a genomic relationship matrix (G) and to lead to predictions of GEBVs. Legarra et al. (2009 and 2014) and Aguilar et al. (2010) developed an extension of this model denoted as single-step GBLUP, which allows simultaneously predicting the breeding values for genotyped and non-genotyped individuals. All these can be pretested using the CBBP.

3.3 Definition of breeding objectives

The success of CBBPs depends on understanding livestock keepers' breeding objectives and selection criteria. To do so, homogeneity and heterogeneity of breeding objectives and selection criteria need to be assessed among community members and between neighboring communities. Uniform and consistent views among farmers facilitate the creation of a common understanding and a clear formulation of common objectives.

The long-term economic benefits of keeping certain breeds or breed combinations depend on market demand for livestock and livestock products; as such, data on current and predicted consumer demands (e.g. size of carcass and meat quality) from myriad markets—including traders, abattoirs, butchers, food industries, restaurants, and in some cases, individual consumers (end-users)—must be collected and analyzed.

A cross-check of community breeding objectives and market demands allow a validation of the suitability of current objectives. The findings from the market study have to be presented to involved communities, and in the case of discrepancies, should be adjusted.

Different participatory approaches can be used to describe community breeding objectives. Some of these methods are briefly described below and advantages and disadvantages of each method are summarized in Table 2.

3.2.3 Personal interviews

One option, often the starting point in defining breeding objectives, is to interview individual farmers and ask each of them to list and describe the traits that are of economic interest to them and what selection criteria they employ toward achieving the stated objectives. This process is best done with key and knowledgeable, not necessarily all, local villagers. It is then followed by asking or facilitating producers to independently rank or assign a score for each of the traits or trait categories; respondents should not be influenced by a pre-defined format. If a person does not recall any criteria, the facilitator can help them by suggesting some points; however, forced answers must be avoided.

3.2.4. Workshops (focus group discussions)

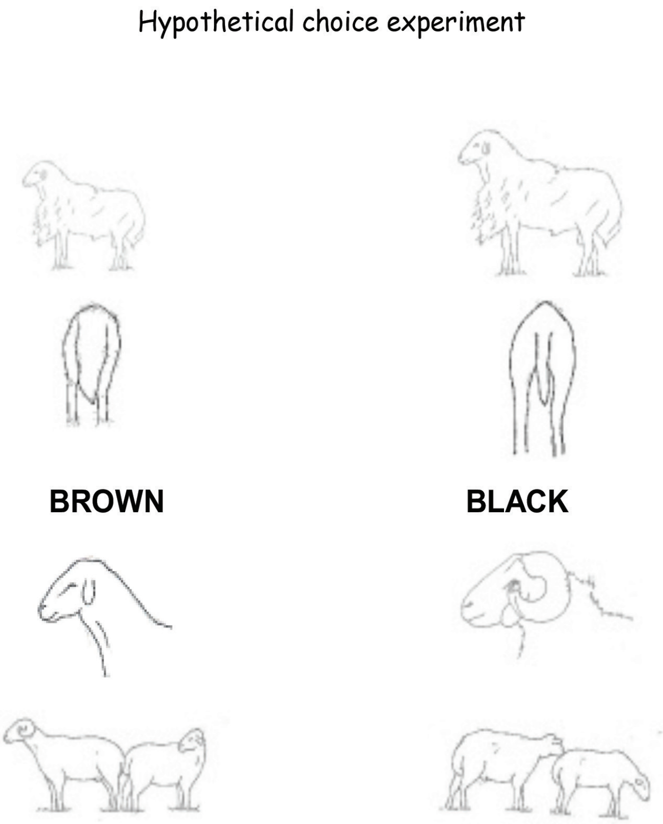
A group of 8–15 persons can be invited to discuss their opinions on breeding objectives and selection criteria. Such a workshop has to be facilitated by at least two persons: one moderating the discussion and one recording the information on a flip chart or board. Where necessary, an interpreter should be used to ensure ongoing clear and common understanding. The information should be clearly presented and made visible, and where necessary, diagrams or charts should be used to illustrate the issues during the whole workshop to all participants. The task of the moderator is to ensure that each participant can freely express his/her point of view. In such discussions, it is not unusual for participants to generate long lists; however, the facilitator should help the participants to shorten/limit the list to key and most valuable traits only. This is ultimately achieved by pooling related traits, ranking all the re-listed traits, agreeing on said ranks and creating a final list of most valued traits.

3.2.4 Choice cards experiment

To design choice cards experiments, valuable information about farmers' preferences for different traits should be gathered from the survey questionnaire results. Respondents are presented with a series of choice sets, each containing five or six alternative traits. For example, in most of the sheep CBBPs in Ethiopia, six traits for ewes (body size, coat color, mothering ability, lambing interval, twinning rate and tail type) and five traits for rams (body size, coat color, tail type, libido and presence or absence of horns) were used.

From each choice set, respondents are asked to choose their preferred alternative or skip the set. The attributes used are common across all alternatives. Each of the traits is grouped into contrasting classes (i.e. "good" or "bad"). Trait categories are described to interviewees using drawings of hypothetical types of animals (Figure 1). For those traits that cannot be described using drawings, trade-offs between the different trait categories are described verbally. Additional information could be added to the choice cards to investigate interactions between such information and the traits presented in the cards.

Figure 1. Hypothetical choice experiment example, in which choice sets are used to determine ram trait preferences (e.g. body size, tail type, coat color, presence of horn and libido)



Source: Duguma et al. 2011

3.2.5 Ranking of live animals

Ranking of own animals
Participating sheep/goat owners are asked to rank their own animals (female and males) as first (best), second (second best), third and worst, and to indicate reasons for their ranking (Figure 2). After receiving detailed information from the owners, each ranked individual is measured for linear body length, chest girth, heart girth, tail length, tail circumference, and evaluated on body condition and dentition. These two evaluations assess the correlation between the farmers' rankings and actual quantitative measurements taken on animals of same age or age groups and what such relationships/correlations mean. There are usually not many rams/bucks in the flocks and it is often difficult to accomplish this exercise with males.

Image 1. CPPB farmers in a participating Ethiopian community carry out animal rankings

Ranking of animals not known to farmers
Another option is to ask farmers to rank animals which are unknown or unrelated to them (i.e. other peoples' animals). These animals can originate from a research station or from other, distant farming communities. For this method, the focus is first on the phenotypic appearance of the animals. The test persons can then be provided with additional facts on production and reproduction on each animal to further inform his/her decision. It is important that each test person is provided with identical information on a given animal (Box 1 and Image 2).

Box 1. Group ranking of sheep
In the ICARDA–ILRI–BOKU sheep breeding project, 15 ewes and 15 rams were randomly selected from the communities' flocks at each study site, marked and randomly assigned into five sub-groups and then penned together. A total of 30 sheep owners from each site were moved to the other site (each location has two sites) so that farmers were ranking animals with which they were unfamiliar. Each interviewee was asked by an enumerator to rank the animals within each pen according to his/her own preferences and give the reasons why s/he had chosen the animals as first, second and third. Then they were provided with a life history of the animals, including information on productive and reproductive traits to determine whether they would change their rankings.

Image 2. A group of farmers from the ICARDA-ILRI-BOKU sheep breeding project ranking sheep not known to them

To ensure that no selection traits are overlooked, a combination of at least two methods is recommended. Selection traits should have the following features:

- Relate either directly or indirectly to the breeding objectives
- Easy to measure under field conditions
- Heritable
- Not too many (not more than three under smallholder situations)
- Relationships between selection traits should be understood; antagonistic relationships (i.e. traits that are negatively genetically correlated) between two traits mean improvement in one trait will result in the deterioration of another trait

One difficulty is how to include adaptive traits of local breeds to various environmental stress factors (e.g. diseases, internal and external parasites, water scarcity and walking ability). These traits are often difficult to record under field conditions. However, given that these are extremely important traits for small ruminant production in tropical and other harsh environments, they should be accounted for in selection decisions. For example, resistance to internal parasites could be measured by fecal egg counts (easy to measure) and has been shown to be heritable (Baker 1998). Because all animals are equally exposed to the same stress factors, often to similar magnitudes, the best performing animals under the given production environment must be the best adapted to the prevailing conditions. For example, under conditions where animals all graze on poor quality pastures, the fastest growing animals must be those best able to cope with such forages and hence should be selected as future sires and dams.

Table 2. Advantages and disadvantages of alternative methods of defining breeding objectives

Properties	Personal interviews	Workshops	Choice cards	Ranking of live animals	
				Ranking of own animals	Ranking of animals unknown to farmers
Advantages	A large number of persons can be interviewed Possible to verify the consistency of responses Additional information can be gathered at the same time	Information from different persons collected at once Differences can be discussed directly	Large sample size Enumerator-introduced bias likely to be lower than in interviews Price can be included as a characteristic	Relatively easy to handle Closer to reality than choice cards: Seeing a live animal is better than a picture Information from different family members can be considered Allows evaluation of functional, adaptive and reproductive traits not shown by conformation but known to the owner	Easily done by farmers Closer to reality than choice cards: seeing a live animal is better than a picture
Disadvantages	Language barrier Enumerator-introduced bias may be high Important traits may not be mentioned	Some people (e.g. with higher social status) might dominate the discussion	Limited number of animal profile choices can be made per person Visual illustration of some traits can be complicated or impossible	There may not be enough animals of the same category available in small herds	Large “pool” of animals often not readily available Hypothetical life history provided with a given animal may not be compatible with the visual appearance according to farmers’ experience Limit to the number of additional traits that can be included

Source: Authors’ notes

3.4 Assessment of alternative breeding plans

There is no single best method for designing breeding plans to fit all possible circumstances. Thus, one option is to evaluate the results of alternative designs through modeling in order to choose the best under the given circumstances. There are two basic approaches for modeling and evaluating breeding programs: deterministic and stochastic models.

Stochastic simulation is the easiest of the two. The breeding program is simulated in detail on a computer, mimicking a true breeding program in detail with more precision because all individual animal characteristics are accurate. Its disadvantages include time and computer power requirements and ultimately, the user does not gain much insight compared to the deterministic approach. Simulation of a large number of replicates of a large breeding scheme may take from several hours to days, making the approach less suitable as an operational tool to quickly evaluate alternative schemes. Since stochastic simulation does not explicitly model mechanisms (e.g. accuracy and generation interval) the user may not be able to appreciate the relationship between the determinants. Hence it is difficult to extend results to other breeding schemes that have not been simulated. Examples of the stochastic computer programs include ADAM, EVA and SixS.

The deterministic method does not mimic the breeding program on the individual animal level but uses deterministic equations and population parameters to predict gain and inbreeding. Hence it requires more insight into quantitative population genetics than stochastic simulation. Advantages of deterministic methods are short computation time (many alternatives can be computed within a limited time) and it provides in-depth insights into gain and inbreeding within breeding programs because the mechanisms are modeled explicitly. Few software packages are available for deterministic modeling, e.g. ZPLAN, ZPLAN+ and SelAction.

ZPLAN, which was developed in 1980s at the University of Hohenheim, Germany, is the most widely used deterministic modeling software. It was designed to optimize livestock breeding strategies by deterministic calculations. It evaluates both the genetic and economic efficiency of breeding programs considering one selection cycle. ZPLAN is written in FORTRAN and allows flexible modification of existing subroutines to model desired breeding scenarios as realistically as possible. A more recent and web-based version of the software, ZPLAN+, is also available but requires a subscription. The older version is freely accessible.

Core competencies and benefits of ZPLAN+ include:

1. a comprehensive range of functions and consideration of recent developments to account for complex breeding programs with special emphasis on genomic information. (It does not consider options where crossbreeding may be part of the breeding program);
2. programming based on modern platforms (object-oriented programming, platform-independent software, database driven web-applications which enable the user to work from anywhere; and
3. user-friendly interfaces with online documentation and support.

The optimization of a particular breeding program in both ZPLAN and ZPLAN+ is based on three functional core areas: selection index procedure for predicting reliabilities, gene flow method and complex economic modeling. Important outcomes of ZPLAN/ZPLAN+ include annual monetary genetic gain for the aggregate genotype, annual genetic gain for each single trait and discounted return and discounted profit for a given investment period.

Depending on the particular situation, the design and evaluation of a potential breeding program must take the following into account in ZPLAN/ZPLAN+:

- Defining of tiers in the breeding plan.
- Defining of sexes in the selection group.
- Indication of paths of gene transfer from one group to the other.

Users define and determine input parameters (input files), including population, biological and economic cost parameters. Furthermore, phenotypic and genetic constants/parameters are required for modeling alternative breeding plans (Box 2).

Once a breeding program is operational, genetic improvement over the course of the project can be compared with predicted values. Reasons for observed differences, if any, can be examined and new strategies developed to rectify or accelerate progress towards desired outcomes.

3.5 Developing adequate breeding structures

Box 2. Input parameters required to run ZPLAN/ZPLAN+

Input parameters (input files) are defined by the users and can be subdivided into:

1. Population parameters

- Population size (females)
- Number of proven males/year
- roportion of male and female animals in different tiers

2. Biological parameters

- Duration of breeding females' and males' use (time unit)
- Mean age of females and males at birth of first offspring (time unit)
- Mean time between subsequent lambing/kidding/calving (time unit)
- Mean number of offspring per litter (e.g. litter size in sheep and goats)
- Mean number of offspring per female per time unit
- Survival to weaning/yearling

3. Economic/cost parameters for a given investment period

- Fixed and variable costs/breeding female: increased cost per unit should be discounted when calculating relative economic values. These values may vary from breed to breed or from region to region within the same breed. Only additional feed or labor costs spent over the normal husbandry practices have to be included during simulation.
- Interest rates of return and costs: have to be based on real rates of interest/cost (i.e. bank account interest rates of specific region or country). It is commonly recommended to use slightly higher discount rates for returns than for costs, because returns are realized later than costs.
- Investment period is defined in time unit. For instance, for cattle and sheep one-time unit is one year and for pigs it is six months. It has been quite common in animal breeding studies to define the investment period as three or four times the mean generation interval of the particular species under consideration.

Phenotypic and genetic constants:

- Phenotypic and genetic standard deviations for goal traits
- Phenotypic and genetic correlations between each pair of goal traits
- Heritability estimates (heritable fraction of the variance in each trait)
- Repeatability (in case of ZPAN+)

Estimates for phenotypic and genetic constants are lacking for most indigenous breeds in low input systems. In that case, use literature-based information estimated from breeds found in similar production systems or production environments.

3.5.1 The breeding program

Sections 3.1 and 3.2 discussed critical aspects of selecting target communities, farmer groups and breeds in CBBP creation and implementation, including selection of target population for genetic improvement This section of the breeding program manual considers the identified animal population in terms of its biological characteristics, the husbandry practices under which it is raised, prevailing and anticipated infrastructure, as well as the constraints and opportunities—all of which, if appropriately considered, enable the design of a program that maximizes both genetic gain and profit for the community.

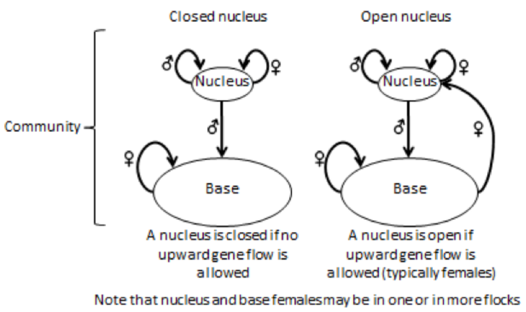
The simplest and most straightforward design is one in which the best males and females are selected as replacements (i.e. the future parents of the next generation) from an entire population. This means that all the herds/flocks in a community are monitored and screened to identify the "best" individual animals. The challenge with such a design is that each member of the participating community has to be somehow involved in the selection process. Each farmer has to therefore undertake performance recording, pedigree recording and rearing of male candidates—in the case of the latter, this is up to some defined age, which may not always be practical.

Performance recording may be kept at a minimum or performed in stages. Rearing of male candidates, at least post-weaning, may be centralized at a test station or may be entrusted to a few select members of the community.

An alternative design is to have some farmers with the "best" animals and often "best or average practices" to breed males for use by the whole population. Such designs with structured populations are called "nucleus systems." Nucleus farmers concentrate on maximizing genetic gains while the remaining "base" farmers can concentrate on production. In this case best males and females are mated in the nucleus in order to produce the "best" next generation of young animals, thus increasing the probability of better gene combinations in nucleus progeny compared to the rest of the population.
For the designs above to deliver, the nucleus must be functional; that is, nucleus farmers not only have to make genetic progress but also have to consistently produce and disseminate appropriate numbers of genetically superior males to nucleus and base populations (farmers' flocks/herds). Thus, the size of the nucleus, or the proportion of females to the total community herd/flock which should be in the nucleus, depends on the number of males needed by the entire system, taking into consideration a desired selection pressure or intensity. A minimum effective population size is also required to avoid inbreeding at the nucleus. For example, if the goal is an annual rate of inbreeding of < 0.5 percent per generation in a nucleus with average generation length of three years, effective population size must be > 33 (e.g. nine males and 100 females). If pedigree information is available and controlled mating is possible, other options to control inbreeding can be designed (e.g. circular mating).

The nucleus can be either closed or open. A closed nucleus means no upward (from base to nucleus) gene flow is allowed, while an open nucleus allows the best animals to enter the nucleus from the base population (Figure 2).

Figure 2. Open and closed nucleus schemes

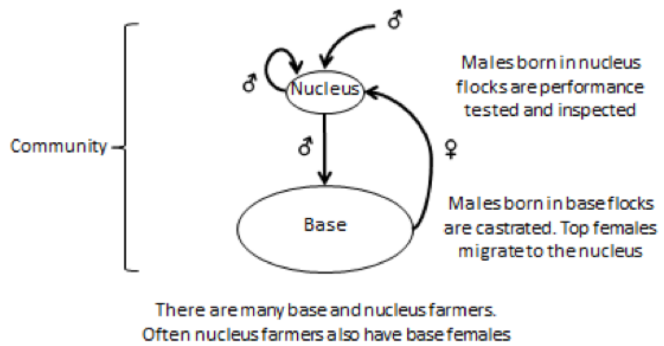


Open nucleus systems require base farmers to do some selection, usually on the females. Usually females for the nucleus are supplied in exchange for males, but other arrangements are possible (e.g. cash, in kind exchanges, or percentage of sales). A very important feature of open nucleus systems is that adaptation traits and other breeding objective preferences in the base population can be secured in the males produced, assuming that such traits are used in the selection of the "best" base females.

Box 3. Open nucleus schemes for Merino sheep
In Argentina, open nucleus systems are common for Merino breeding communities. Nucleus flocks are established with best females and half of their replacements are selected from base flocks. Males are selected on measured performance and visual inspection. Above-average performing rams, which are also visually acceptable, get a special identification from a breeder's society. From these the best remain in the nucleus and the next best are used in the base flocks.

Another feature of open nucleus systems is that, relative to a closed nucleus, inbreeding rates are reduced and genetic progress increased. A typical open nucleus design is to have 5–15 percent of the total female population in the nucleus and to have about half of the nucleus replacements come from the base. For example, a community with a total of 700 breeding females would need about 70 breeding females in the nucleus. If 20 nucleus female replacements are needed each year, 10 should be selected from nucleus progeny and the other 10 from base progeny. The proportion of females in the nucleus and the proportion of base females going to the nucleus can be smaller if selection is more accurate in the nucleus, reproduction rates are high, or if the female to male ratio is high.

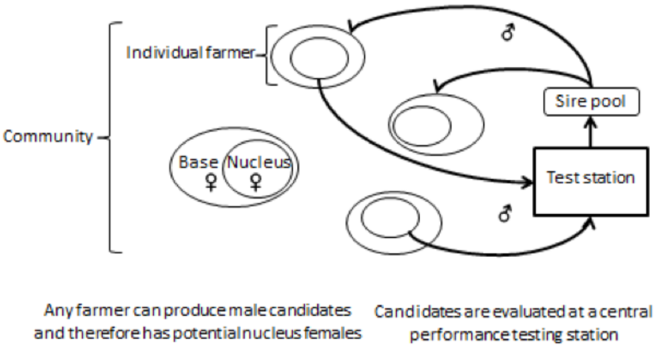
Figure 3. Open nucleus structures: nucleus and base flocks at the Merino sheep breeding program, Argentina



An ideal scenario assumes that the animals of nucleus farmers breed males since all of the females are supposed to be the "best" of the flock. This is not necessarily the case as a nucleus farmer may also have inferior females. In this case the nucleus farmer may identify his/her "best" females and mate only these with the "best" males, or he/she may mate all his/her females with the "best" males but consider for selection only the progeny of said females. There will be several nucleus farmers with only some of their females qualifying as nucleus animals. Such a system requires controlled mating at the nucleus farm or early castration of male progeny from non-nucleus females.

For practical reasons, it is difficult for the individual farmer to raise male candidates from birth until final selection. Variations in level of husbandry between farms can create serious confounding, making clean separation between genetic and environmental superiority rather difficult. To get around such a problem, young candidate males—usually at weaning—can be gathered and placed in one common station or farm. When kept together, the performance of the males can be monitored under the same conditions for a fixed period of time. This process is known as "performance testing" and the common station as the "performance-testing station." Such a station may belong to the community itself or may be facilitated by an external organization. In cases where nuclei are run and managed by several farmers, but all following similar management procedures and selection processes, then the nucleus is referred to as "dispersed" (Figure 4).

Figure 4. Open nucleus structures: a dispersed nucleus



There are also programs with a single nucleus-farmer who produces males for a group of farmers. Such systems are also called "group breeding systems." The principles of open nucleus systems apply; however, considering that 5–15 percent of the female population should be in the nucleus, group breeding schemes are appropriate for farmers with large herds (typically >100 breeding females each).

For smallholders, large individual flocks are uncommon, but examples of community single-nucleus flocks or cooperative-nucleus flocks exist (Mueller et al. 2002). Sometimes a single 'central' nucleus is run by an external organization such as a university or a governmental body. In this case, the design essentials regarding nucleus size and gene flow still apply but the control of the community over its breeding program may be low. Nevertheless, there are also examples of community breeding systems which started with a "centralized" nucleus and developed into a dispersed nucleus system. Such dispersed nuclei may, in turn, develop into reference sire schemes and eventually into population-wide evaluation schemes.

In conclusion, there are many alternative breeding structures and tools for their optimization. The tools are useful for the strategic optimization of a breeding program. In practice, however, many variables are fixed and rarely can a program start with an optimum structure in terms of layer size and gene flows. Thus, practical situations need tactical optimization, which means finding the best solution at each step of the program while having a target structure in mind.

3.5.2 Animal identification

Animal identification is crucial in genetic improvement programs. Animals should be uniquely identified, so as to accurately trace their respective pedigrees and link the performance of individual animals to her/his progeny and relatives through known genetic relationships. Combining performance and pedigree records enables more accurate computations of the genetic worth or breeding values of the animals to be estimated or predicted and used for selection.

The identification methods employed can vary between regions and communities. Ear tags, collars, tattoos, branding and ear notches can be used. Ear tags are the most commonly used identification methods because they are relatively cheap, easy to apply and are less stressful to animals. However, in some situations, where for some reasons ear tags are not acceptable or practical—because of cultural taboos or shape of the ear, for example—other alternatives can be sought.

Unique numbering should be embraced, such that no two animals in the breeding program have the same identity, both in time and space. The Ethiopian CBBPs implemented by ICARDA used a unique identification/numbering system (five digits) per community. Plain plastic ear tags were procured, identification numbers were hand-written using indelible markers and all animals belonging to community member households were ear-tagged.

Ideally, unique ID usage should extend beyond each CBBP so that the processes can be scaled up to other communities and all of the CBBPs eventually managed within the same database. It would then be possible to distinguish individual animals belonging to different CBBPs and even regions. Animal IDs may also be used for traceability of animals/meat.

Image 3. Unique animal identification system using ear tags, wherein ID numbers are handwritten with indelible markers

The identification of the base population can also be undertaken by a research/extension team. Thereafter, identification of newly born lambs could be undertaken by village enumerators. Ultimately, community members should be trained to handle animal identification by themselves. Some communities may not be willing to ear tag very young animals because of the perceived stress it may cause. In such situations, an identification number can be assigned to newborn animals and the tag kept with the family. Some form of identification should be recorded and the animals ultimately tagged when the owners feel it is appropriate to do so.

3.5.3 Data recording and management

Development and use of a simple, flexible and cost-effective performance recording and evaluation system is essential for a breeding program. Recording formats should be kept as simple and as practical as possible for easy use and adoption.

In accordance with the agreed selection traits, the Ethiopian CBBP developed three recording templates for each location: two for ewes/does and one for lambs/kids. The ewe/doe templates contained information such as lambing/kidding date, parity and litter size. One of the ewe/doe data templates had detailed information (Annex 1) and was kept with the enumerator. The second ewe/doe data template, however, had little information to be recorded by the household and was kept by each household. The lamb/kid data template had information about lamb/kid identity and performance. The research team developed these templates after a thorough discussion with the community. Other simple formats can be developed to fit to existing set-ups.

In many of the CBBPs in Ethiopia, major traits considered for all breeds included weight (at birth, weaning, six months and yearling) and number of lambs weaned. Also factored in were milk yield for goats and sheep in pastoral areas, and where there were no feed shortages (e.g. in the Bonga and Horro areas of Ethiopia), number of lambs born (twinning).

The ultimate goal of a CBBP should be to ensure that the community can eventually handle major activities required for the program to be functional at the community level. Government support, especially administrative and technical assistance undertaken by extension services, however, is extremely important to sustain such programs. Such support includes employment of an enumerator for each community to assist households in animal identification, measurement and record keeping, reporting for genetic evaluations, and to provide continuous training on how to do it. All necessary supplies and equipment (e.g. record books, weighing scales, ear tags and markers) should be made available by the development, extension and research teams for effective recording and follow-up until the community masters the major activities.

Appropriate training is crucial for success and should be organized for both enumerators and the community and offered in easily digestible components (i.e. not rushed or offered all at once). The type of data collection and its frequency need to be decided upon in close consultation with the community and must be based on the agreed breeding objectives and selection traits. The simpler the process, the better, and thus, the higher the probability of its sustainability. The initial focus should be on a few key traits only (about three or four), with additional traits added on as necessary as groups mature and become more sophisticated.

It is also important to identify individual family members in each household to be in charge of the data recording and handling. It is sometimes useful to engage school children, as adults might be illiterate. In this case, supervision by an adult ensures that data are recorded on time and kept in a safe place (Image 4 and Table 3).

Image 4. Performance records used in the ICARDA–ILRI–BOKU sheep project

The type of data and frequency of collection used in three Ethiopian communities are summarized in Table 3.

Table 3. Traits recorded in three sheep breed improvement communities in Ethiopia

Traits	Bonga	Horro	Menz
Body weight			
- Birth weight	√	√	√
- Three-months weight	√	√	√
- Six-months weight	√	√	√
- Yearling weight	√	√	√
Lamb survival	√	√	√
Twinning rate	√	√	

Source: Authors' notes

Support in data entry and processing should be provided by the extension and research group. The local or partnering research institution can play this role, but once the database is developed and in place, the database can be updated on a near real-time basis through innovative use of aids such as cell phones and verified via the same devices. Centralized data management tools facilitate easy data capture, analysis and reporting. Simple indices based on the set selection criteria for each breed should be developed and the overall merit values computed and shared with the communities and farmers as part of the feedback and for use to effect selection. In partnership with EMBRAPA-goat and sheep (Brazil) ICARDA and its partners developed a Data Recording and Management System (DREMS) which enables the recording, storage and management of information generated in flocks of goats and sheep. This system can be made available to those who wish to use it in their CBBPs.

3.5.4 Selection of candidate rams/bucks

Young rams should be selected based on recorded data (own and maternal performance) for the set of agreed selection traits. Selection can be undertaken at different stages. For example, the first stage can involve culling of animals with undesirable phenotypic characteristics (e.g. tail type, coat color, horns, conformation and general appearance) and clearly observable defects (e.g. small scrotum size, testicle deformation and undershot or overshot palates). The retained individuals are then further judged based on body weight and conformation traits (e.g. weights at birth, weaning, six months and one-year, functional conformation and body scores reflecting carcass value and ramp size relative to contemporaries, and information on mother's attributes). The stages at which the selection process takes place depend on both the existing traditional practices of ram/buck selection and use, as well as on scientific and practical requirements. If the selection decision can be made in line with traditional practices, it will improve the probability of acceptance by the community.

It is important to cull undesirable males before they reach puberty (i.e. before they can serve). Depending on the species and breed, this can be as early as 6–8 months of age. Where communal grazing is practiced, synchrony and agreement on when to cull is important as flocks can meet in common pastureland or watering points, when the undesired males can breed, and hence reduce the selection impact. It is also important that the selected young males are effectively used for breeding before they are sold off in order to avoid negative selection.

When the breeding program is fully functional, the best rams/bucks should be identified by their breeding value as computed from recorded data and based on their pedigree. Animal models can be used to rank rams/bucks. If breeding values cannot be computed for whatever reason, rams/bucks can be selected based on simple index values that are computed from the available recorded data from the site population. The community has to be actively involved in the selection process so that ram/buck ranking closely matches the community's own valuations, goals and desires as much as possible. This helps to build trust and confidence, buy-in and a sense of belonging among the beneficiary community that increases both their confidence in the selected rams/bucks and ownership of the process.

Box 4. Selection of rams

In the ICARDA–ILRI–BOKU project two stages of selection were applied: initial screening at the age when first sales of young rams occur (4–6 months) and final selection for admission for breeding at 12 months of age. All young rams are collected at one central place in each community on an agreed screening date. Selection is then carried out based on the data analyzed. A breeding ram selection committee composed of about 3–5 members elected by the community are involved in the selection. For example, 20 rams are pre-selected on their breeding value from 100 candidates. The final selection (15) is determined by a final culling and chosen by the committee. The joint selection process strengthens the linkages between farmers, extension specialists and researchers.

Animal exhibitions or shows can be linked to the ram/buck selection events. During such shows, animals of different sexes and age categories are ranked and the best ones are awarded prices along with the best young rams/bucks. Animal shows are important as they can create awareness at the community level of the higher relative worth of selected breeding animals. Individual livestock keepers who manage their flocks and records better can also be recognized during these types of shows, thus creating healthy competition—and a display of best practices—among community members. This also carries a social component as winners are recognized in public and thus awarded special status, with pride to the winners and respect from the community. During selections and shows, judging should be done through a participatory process, and preferably by a panel of committee members formed and nominated by local site farmers/pastoralists. This creates some form of independence and transparency.

Image 5. Rosettes are awarded to the best breeding of rams and goats at community shows

3.5.5 Management and use of breeding rams/bucks

In cases where individual farmer flocks are quite small, the flocks should be treated as one flock. Selection is undertaken at the community-flock level, with the selected best rams shared among the community members thereafter. This is often the case in smallholder mixed crop-livestock systems. In some communities such tradition of ram sharing may already exist; however, in other communities, members may be reluctant to share rams outside their established social networks. Repeated consultations should be made with the community to arrive at an agreed modality as there is no best single arrangement that applies to all situations.

For example, in Ethiopian CBBPs, the following modalities for ram/buck exchanges were discussed:

- Sharing rams/bucks based on friendship and trust among members of the breeding group
- Exchanging rams/bucks based on a written agreement
- Exchanging rams/bucks based on purchase between different breeding groups when rams/bucks completed the defined service period in a given flock
- Advancing seed money from projects/government or from members' contributions to purchase first-round

breeding rams/bucks, using these, then selling them to generate a revolving fund to purchase the next and subsequent rounds of breeding rams/bucks

It should be noted that one or a combination of the above arrangements may be adopted or used depending on the prevailing circumstances. The last option has been most commonly used in past CBBPs. Creating a revolving fund can help sustain the program in the long term. It also helps to prevent the negative selection of rams/bucks that is a common phenomenon in the communities. Negative selection arises from faster growing males being sold off before they are of breeding age, leaving the slower growing males as the breeding males in community flocks. To avert negative selection, the best young rams/bucks are purchased by a project/government/ contribution from members and are owned and used by the community. After two years of service (period to be agreed with the community), such rams/bucks are either sold as breeding animals to other communities or are fattened and sold to support the purchase of the next group of selected rams/ bucks for the community. Mechanisms of how to use the revolving funds and how to share and distribute benefits have to be agreed upon; therefore, it is paramount to establish bylaws and an administrative procedure.

The best way to use rams/bucks communally is by forming "ram/buck-user-groups." This can be based on criteria such as number of breeding ewes/does, settlement patterns and use of communal grazing areas. Traditional ram/buck use groups are often based on social networks and resource availability and thus these should be considered where and when applicable. In order to minimize inbreeding, a ram/buck rotation strategy among the ram/buck groups has to be established through a consultative process. The best way is to use a ram/buck in the flocks for one year, after which it is rotated to another group within the community. Ram/buck rotation records must be diligently kept to avoid inbreeding.

The management of selected breeding rams/bucks to be used by the community should be based on pre-agreed modalities. Some of the options include:

- Managing the ram/buck in rotation
- Keeping the ram/buck in one agreed household and those who use the ram/buck pay an agreed amount for the service
- Keeping the ram/buck in one agreed household and other community members contribute in kind (e.g. feed and veterinary drugs) to keeping the ram/buck

A critical issue that needs to be thought through is how to manage unselected rams/bucks. It should be recognized that unselected rams/bucks, especially those young rams/bucks that fulfilled the initial requirements but were ultimately eliminated from the selection process, are still likely to be genetically better than many of the males in neighboring communities where no selection programs exist. This will be particularly true after several generations of selection. Therefore, mechanisms should be designed to sell these rams/bucks. Value addition, like fattening for example, could be organized for the unselected rams/bucks and linked to markets. If the animals can be pooled together for targeted markets then their value could be much higher than if they were individually sold.

3.5.6. Institutional backup: organizational issues

Community-based breeding programs need to be initially supported by a committed team of researchers, extension personnel, the NGO community and program staff. The institutional backup needed to implement such a project can vary depending on expertise and resource availability. For illustration, the organizational structure used in the sheep and goat CBBPs in Ethiopia is presented in Table 4 but note that not all community-based breeding programs necessarily need to emulate that construction. Local communities—and their supporting national research institutions— must have sufficient learning curves and continued government support before the former can take over full responsibilities and ensure sustainability and success.

Table 4. Structure of community-based sheep breeding implementation team in the ICARDA–ILRI–BOKU sheep project

Project level	Project Coordinator (PC) (plus quantitative geneticist for technical backstopping)	Provide overall project leadership/admin Liaises with project partners Makes project reports Assists in record keeping and genetic evaluation
Site level	Senior researcher (Site Level Team Leader, SLTL) Other scientists District office of Agriculture/livestock (extension service)	Oversee activities including breeding/selection on the site Responsible for record keeping and genetic evaluation
Community level/Team	Community leader Community representatives (elected focal point) as committee/council members, elders, women, youth, government representative (development agent)	Provide community-level leadership Provide links to, liaise between project site level with the community Report community-level developments relevant to the project Champion for the project at community level Assist project logistics at community level Feedback on progress of project activities
Graduate fellows		Look at critical aspects of the project

Source: Authors' notes

3.6 Reproductive technologies for scaling up the benefits from CBBPs

Currently, improved rams and bucks produced by the CBBPs are shared to serve the ewes/ does in the communities. There is compelling evidence that improved rams/bucks bring genetic progress where they are used as has been highlighted in previous sections of these guidelines. Features inherent to the production systems, in particular in small flock sizes, mean that the reproductive impact of the improved sires is limited. Whether the ram is placed at the level of the household or when the ram is being used collectively at the level of the community under common natural mating practices, a ram with a high-breeding value may only mate with a very limited number of females (20–30) during the mating season. To scale up the genetic progress made and expand the use of improved rams/bucks, reproductive options may be brought up together in specific packages to support delivering improved genetics. Using fresh cooled or uncooled semen, a ram may produce at least 300 to 400 semen doses for a mating season of 6–8 weeks. Assuming an average conception rate of 50 percent and a litter size of one for ease of calculation, then improved genetic material will be passed on to at least 150 to 200 offspring. This step also allows the CBBP to go outside directly- participating communities, bringing improved traits into the population. Artificial insemination (AI) remains the primary universal method for dissemination of improved genetics in livestock species, especially in cattle and swine breeding. Artificial insemination is a staged technology with various levels of infrastructure, semen technology, technicity and field organization. Insemination using fresh semen collected in the field and relying on basic infrastructure is regarded as a promising technology for a wider delivery of improved genetics under low input systems. This facilitates reaching more farmers within the communities and also reaching out to other neighboring communities. This section of the guidelines will address selection of females, synchronization of oestrus and ovulations, and semen handling and inseminations.

3.6.1 Selection of the females to be inseminated

To maximize dissemination of genetic progress through AI, it is very important that inseminations are managed carefully to ensure high conception rates. Satisfactory conception rates after artificial insemination with fresh semen under field conditions usually vary between 30–60 percent. Ensuring normal fertility in the flocks is essential for productivity and, therefore, care should be taken to ensure that females that do not conceive are mated naturally, even if the males used are not selected within the CBBP. Contextually, cost benefit studies should be carried out to assess the feasibility of AI in comparison to natural mating protocols. Such cost benefit studies should not only be limited to the cost of interventions (e.g. AI supplies, oestrous synchronization, etc. – see section 3.6.2.) but should also assess the superior genetic gain with AI in comparison to natural mating and any possible benefits of disease control and decreased ram maintenance costs. Much of the variation in conception rates after AI is related to the choice of the females to be inseminated. This step requires good planning, sufficient time and rigor. Locally available data on the reproductive history of the females is important during selection. Key elements to adhere to during female selection for AI include the following:

- Plan AI during the season when high conception rates can be achieved. Avoid periods when animals may be in anoestrus (seasonal – lactational – nutritional),
- Select only adult females with a good record of successful parturitions and good mothering abilities. The response of maiden ewes to synchronization and cervical AI is usually very low;
- Avoid selecting females still suckling their lambs. Suckling can depress conception rates after AI or natural mating;
- Take care to select females with a body condition score not less than 2.5. Females with low body condition are not fit for reproduction; ideal body condition scores for maximum conception are 3.5 to 4.0. Feed supplementation of the selected females may be required for the animals to reach this level of condition by insemination time; and
- Avoid any abrupt changes in the diets prior to, during and after the inseminations and do not expose the females to any management stress (e.g. vaccinations, walking or grazing over long distances, etc.)

3.6.2 Synchronizing oestrus and ovulations

Fixed-time artificial insemination relies on well-timed synchronization of oestrus and ovulations. Economically and technically, there are no advantages to inseminating individual females upon display of naturally occurring oestrus. The choice of the protocol for synchronization depends on the reproductive features of the target breed, the season and the relative ease of implementing the protocol in the field and its cost. One major characteristic of reproduction in sheep and goat breeds in East Africa is the low seasonality as a result of a shallow anoestrus. For example, sheep and goat breeds in Ethiopia are year-round breeders and this enlarges the spectrum of synchronization protocols.

Two common synchronization methods are 1) progestogen-impregnated sponges and equine chorionic gonadotropin (eCG, also designed as PMSG); and 2) prostaglandin analogues. Descriptions of the different synchronization protocols and the conditions for their use are specified below:

- Progestogen-impregnated sponges and eCG injections are the most widely used protocol to synchronize female sheep and goats. The protocol is very effective and yields more than 90 percent synchronization amongst treated females. Under conditions where seasonality of the female sheep is very low, this protocol—which is expensive, requires technicity and may have some side effects including vaginal irritation—should be used only when there is a high probability of having females in condition of anoestrus. Sponges impregnated with progestogen (40 mg) should be inserted and left for 14 days. At the time of sponge removal, a single dose of 200 to 400 I.U. of eCG should be injected intramuscularly. The dose of eCG should be adapted to the format of the breed. Small breeds can receive from 200 to 300 I.U. while a dose of 400 I.U. is needed for breeds with a large format. Inseminations are carried out 52 to 55 hours after sponge removal and eCG injection.
- Oestrous synchronization with prostaglandin analogues—prostaglandin analogues are effective in synchronizing females bearing active corpus luteum. This technique is therefore limited and to be used when females are spontaneously ovulating, i.e. in their natural breeding season. This protocol is simple to use and is much cheaper than the standard progestogen and eCG protocol. There are two variants of the protocol. Females can either be synchronized with one single injection of a prostaglandin analogue or two injections 11 days apart. Injections should be administered through the intramuscularly route. The variant with two injections allows a slightly higher number of females to be synchronized and reduces the spread of oestrus. With these prostaglandin analogue-based protocols, females can be inseminated between 48 and 50 hours after the last injection.

Synchronizing with a prostaglandin analogue may cause abortions if selected females are pregnant. There is a high likelihood for such an incident in the target production systems and therefore, an improvement of the protocol was introduced which consists of scanning all the recipient ewes for pregnancy using portable ultrasound devices prior to synchronization.

In addition to the standard protocol relying on the use of exogenous progestogen (vaginal sponges) associated with eCG, other protocols—using one versus two injections of a prostaglandin analogue and the association between analogues of GnRH and prostaglandins—can be potentially used to synchronize female sheep. In Ethiopia, and under the conditions of the villages where CBBPs are implemented, the cost of the conventional protocol using progestogen sponges and eCG is USD8.5 while the protocol using two injections of prostaglandins is only USD1.3. Furthermore, progestogen sponges and eCG are not yet registered in the country while prostaglandins analogues are registered and available at the local market. This element is crucially important if AI is to develop as a business model.

Image 6. An ultrasound pregnancy diagnosis of a Bonga ewe prior to application of the synchronization protocol

3.6.3 Semen handling and inseminations

The working environment of many CBBPs involves extensive production systems where central laboratories for semen production do not exist or are very distant from the villages and the communities where the inseminations carried out. For these reasons, mobile, low-infrastructure labs relying on the use of generators to provide electricity and using fresh non-cooled semen from the top ranked rams are often the only feasible approach for semen collection. Such labs have been developed for many CBBPs in Ethiopia. The labs can can produce fresh-cooled semen at 15˚C, which can extend the time lag between semen collection and insemination to 4–6 hours, giving more opportunities to reach far-off communities and villages.

Semen collection and insemination acts include the following steps:

1. Semen collection using an artificial vagina in the presence of a female induced in oestrus.
2. Measurement of the ejaculate volume and appreciation of the color and the consistency of the ejaculate. Volumes less than 0.5 ml are generally not used and watery ejaculates (low concentration) or with a distinct yellow color (suspicion of inflammation) are also discarded.
3. Quick assessment of mass motility under a microscope. Ejaculates with mass motility scores less than three should be discarded.
4. Measurement of the sperm concentration using a portable spectrophotometer pre-calibrated for ram semen (ovine-caprine accuread photometer; IMV®, France). Ejaculates with a concentration less than 3 10^9 sperm ml^{-1} are discarded.
5. While being processed, ejaculates are placed in a thermos flask containing water at 35–37˚C.
6. Ejaculates are then diluted to a final concentration of 400 10^6 sperm in each straw (straw volume 0.25 ml) using a commercial extender for sheep semen (Ovixcell; IMV®, France) kept at 35–37˚C. Final concentration can be further reduced to 300 or even 250 10^6 sperm if the initial quality of the ejaculate is high.
7. Diluted ejaculates are then checked for individual motility under a microscope. Ejaculates with a low proportion of spermatozoa moving rapidly on a straight line (less than 40 percent) are not used.
8. Straws are filled, then sealed with inert packing powder and immediately immersed in a thermos flask filled with water at 35–37˚C.
9. Inseminations should be carried out immediately after packing and sealing. On average, time lag between semen collection and insemination should not exceed 10–12 minutes.

Box 5. Achieving acceptable conception rates in Debre Birhan and Menz

Conception rates of the first artificial insemination trials in Debre Birhan and Menz with fresh semen are considered acceptable in view of the large heterogeneity which characterize the flocks in terms of management, feeding and body condition of the ewes at the time of insemination.

	Debre Birhan	Mehal Meda, Menz	Molale, Menz
Ewes inseminated	67	42	22
Ewes lambing to AI	29	10	7
Apparent conception rate to AI (%)	43.2	23.8	31.8
Ewes pregnant at the time of insemination	0	12	4
Actual conception rate to AI (%)*	43.2	33.3	38.8

Source: Authors' notes
Note: AI= artificial insemination; *Actual conception rate is calculated after subtracting ewes pregnant at the time of insemination from the ewes inseminated.

4. Creating an enabling environment

4.1 Community–implementers' relationships

It is crucial that the program provides the basis for farmers to effectively interact with researchers and extension staff and to openly discuss their fears, doubts and ideas about the program. Workshops should be organized regularly to discuss every step of program design and implementation. Informal consultations with community elders also help to get and disseminate information about the program. It is also vital to provide regular feedback to the farmers. Record sheets of individual flock productivity as deviations from population averages help community members to track performance of their animals compared to those of their peers. Even preliminary results have to be presented and discussed with the farmers, thus giving them the chance to comment and share their opinion with extension specialists and researchers. Such feedback also reduces the risk of misinterpretation of results, which could lead to wrong decisions. The relationships between researchers, extension agents and farmers/pastoralists should be based on trust, transparency and respect, which is expected to evolve through working closely together. An important precondition is to consider and account for the cultural, religious and ethical values of the community.

4.2 Other interventions and services

Ideally, a breeding program should be part of a broader livestock improvement program. Genetic improvement should therefore be complemented by other interventions, notably, access to improved and affordable health services, market information and market services, improved infrastructure and supportive policies. The development and quality assurance of feed resources and supply all year round will ensure that improved genetics are expressed to their optimal genetic potential.

The benefits and effects of complementary interventions are realized within a relatively short period of time, long before the real effects of genetic improvement become apparent or visible. Projects, research and extension departments and NGOs can assist until the community understands the benefits and can start to invest in itself.

All in all, the interventions listed above should be accompanied by capacity building and strengthening for the different actors involved in the program. Capacity building programs should start by identifying participating individuals and organizations, assessing their respective strengths and discerning the main gaps in knowledge, organization and institutional weaknesses at the village and site levels. This should be followed by identifying topics that should be given priority in capacity building/strengthening follow-up training programs.

Below are some of the possible actors and the subject areas that can be targeted for capacity building/ strengthening:

- Livestock keepers, who can benefit from technical support to successfully implement new technologies. One-day workshops and trainings could focus on recording and use of processed records and other feedback information; improved husbandry, especially healthcare; animal housing and feeding; and the essentials of group dynamics, particularly effective group management (e.g. meetings, recording and conflict resolutions). Such training is best supported by practical demonstrations in the form of farmer field schools or reciprocal farm visits to neighboring communities, which stimulate healthy communication and competition among groups and farmers.
- Staff members of extension services also need continuing education courses to learn about emerging technologies and their practical applications, particularly as these staff are key information sources for farmers. Particularly useful topics include animal identification, analyses of records and content and methods/type of feedback to farmers.
- Researchers may need specific training in participatory research methods or to have refresher courses on various aspects of breeding programs. They can also be trained on data recording, analysis and effective reporting.
- The private sector, including drug vendors, veterinary service providers, feed suppliers, traders, brokers, butchers and export abattoirs can also benefit from training and engagement programs.

- Financing and insurance institutions (government and private sector) also need to be involved in capacity building and strengthening follow-up as they are essential bodies in accessing credit and also in establishing community-based insurance systems for livestock.

It is important to note that more often than not, it is the lack of soft skills among community members and the technical support staff that largely lead to the failure of livestock CBBPs. Therefore, it is important to focus on improving the soft skills of participating individuals and bodies, while also simplifying complicated technical aspects of breeding programs.

4.3 Government support

For breeding programs to be sustainable, long-term commitment by local and central governments is essential. The initial costs of performance recording, animal identification and feedback cannot be shouldered by farmers alone, so governments need to be responsible for start-up costs. Additionally, complementary and supportive policies should be developed, implemented and facilitated by the government to ensure sustainability and program success. Adequate funds should be allocated for technical personnel (researchers and extension staff) and infrastructure. Breeding programs require continuous technical and intellectual backstopping from well-trained technicians and researchers.

It is common to find that most of the smallholder and resource-poor livestock keepers have no access to affordable financial services, notably credit. In addition, national budgets for livestock development and research are always limited. Government should therefore facilitate access to credit, land and other resources (e.g. watering points, rural access roads, livestock auction yards and market information on livestock and livestock products). Therefore, there is need for better coordination among the various government departments and agencies, scientists and other development agents involved in such schemes. Such close coordination and networking should be maintained to allow the breeding program to incubate and reach a sustainable stage.

4.4 Market access

There has to be demand for the products (breeding animals, meat animals, other livestock products) of the breeding program in local, national, or international markets to ensure that it is a worthwhile investment. Therefore, market studies should be part of the preparatory phase of the breeding program.
Farmers are encouraged to form cooperatives or farmers associations to ensure better access to markets and stronger negotiation power, which also means a larger number of animals and/or quantity of livestock products can be brought to market regularly. Cooperatives also have easier access to credit and can negotiate with service providers, like the feed industry and veterinarians, for better prices for particular services or products, which can then be ordered in bulk.

Local, regional, national and international market-information—for breed, type, sex, body weight for age and price—is key for market participation and market-orientation of farmers and pastoralists.

4.5 Links with other projects/activities

The problems facing communities are complex and intertwined. Piecemeal approaches to development interventions are undesirable and are usually more costly in the long run. Thus, it is of paramount importance to follow a holistic development approach for sustainable development of communities, necessitating integration and coordination.

As much as possible, it is recommended to try and link breeding programs to other ongoing development initiatives and activities in the local area. This positively exploits potential synergies, reduces redundancies and overall strengthens the projects. For example, an NGO wants to offer training courses to farmers: members of the breeding program can participate in these courses, which would benefit the breeding program with additional expertise and funding.

5. Monitoring and evaluation

An integral component of a functional community-based breeding program is monitoring technical and management issues related to the implementation of the breeding program; whether outputs, outcomes and impacts are achieved or achievable; and whether mechanisms to ensure sustainability of the breeding program are in place.

Ultimately, a breeding program should be evaluated by genetic improvements achieved in all important traits and the effects on total output of products and outputs per unit of measurement, e.g. per animal and the economic impacts at both household and community levels. Ideally, outputs should be related to inputs and the status of the natural resources utilized. These change with time and must be revised accordingly. By regularly monitoring the breeding program, corrective measures can be taken to improve it. Showing the impact of the breeding program will be essential for ensuring continuous support of the program.

To ensure effective monitoring and evaluation, the breeding program team should define key indicators to measure the progress in achieving the main outputs of the breeding program, as well as indicators to assess whether or not program outputs are contributing, or will eventually contribute, to the desired outcomes and impacts at the individual flock, household and community levels. Appropriate tools and procedures for monitoring these indicators have to be devised and should include clearly defined timelines for each indicator. Although the details have to be specified individually for each breeding program, it is expected that the monitoring and evaluation system for the Ethiopian CBBP proposed in Table 5 is relevant and applicable for other small ruminant breeding programs.

Table 5. Monitoring and evaluation of community-based breeding programs for sheep and goats

Parameters	Indicators	How to Monitor	When to Monitor
Technical issues related to implementation of the breeding program:	Functionality of the scheme is measured by the points listed below:		
Proper animal identification	• Percentage of ear-tagged animals in participating households	• Follow-up/control in each participating household through enumerators	Continuous
Proper data collection, analysis and use	• Number of farmers involved/dropped out • Estimated breeding values of rams/bucks available at time of selection	• Follow-up/control in each participating household through enumerators	• Continuous • At each selection event
Selection and management of rams/bucks	• Accurate selection of best rams/bucks with the community at agreed intervals • Number of active rams/ bucks included/culled • Community use of revolving funds to buy rams/bucks	• Organization and documentation of selection events through NARS • Detailed accounts kept by community of how revolving funds are being managed and used	At each selection event
Ram/buck sharing	• Selected rams/bucks shared and used as planned • Bylaws for ram/ buck purchase and sharing developed and implemented	• Follow-up and documentation by community committee • Documentation by NARS of whether agreed modality is followed or, if there are changes occurring, the reasons for the changes	Regular intervals

Parameters	Indicators	How to Monitor	When to Monitor
Establishing breeders associations/cooperatives	• Number and participants of formal or informal breeders associations/ cooperatives	• Documentation by NARS	After three years
Complementary interventions: • Value addition for unselected rams • Feed supply • Disease prevention and treatment measures • Proper market linkages	• Number of fattened rams/ bucks sold and cost–benefit of fattening • Increased quality feed supply • Productivity losses and mortality reduced • Market prices achieved for breeding and meat animals sold by participating households	• Monitoring of quality and continuous supply of feed for flocks and for fattening by enumerators and NARS • Flock records and follow-up of health of flocks and shared rams/bucks by animal health workers and vets • Recording of animal sales by households and additional rapid surveys with traders	Regular intervals
Program outputs			
Level of engagement of the actors in program activities	• Active community breeder committees at each site • Attitudinal change among different actors in the livestock development	• Detailed studies on the behavior of different actors (comparison against the base year when the program started)	After 2–3 years and repeated in subsequent years
Superiority of breeding animals	• Appearance and performance of the selected animals is better than their contemporaries • Demand from neighbors, etc. for breeding stock produced by the breeding program • Higher price paid for breeding animals originating from the program	• Evaluation of visual observation and performance of the selected versus non-selected rams/bucks by community and NARS • Recording of sales and market prices for selected rams/bucks by owners	At each ram/buck selection
Breeding progress	• Genetic and economic gain achieved by the program	• Detailed analysis of genetic and economic gain • Estimation of breeding values of rams/ bucks and breeding progress by NARS	Annually
Outcomes and impacts			
Involvement of the community and acceptability of the scheme	• Regular feedback from beneficiaries received and documented • Dropouts of participants	• Meetings with individuals and the community • Documentation by community committee and NARS	Regular intervals Continuous
Livelihood improvement	• Productivity gain at animal and flock level • Changes in the livelihoods (income, food availability and work sharing) of participating households	• Analysis of flock records • Analysis of incomes as well as consumption patterns of households (flock records and rapid surveys) against baseline information collected at program initiation	• After 3–4 years • After five years

Parameters	Indicators	How to Monitor	When to Monitor
Sustainability of the breeding program	• Economic gains from the breeding programs need to be evaluated • Program being implemented with little ‘external’ support over long period of time • Feasibility of the program in terms of economic, social and natural resources dimensions	• Project-related financial expenditures need to be monitored and reports prepared according to plans • Assessment of whether there are any external supports to the program • Survey • Impact modeling	Every 3–5 years

6. Concluding remarks

Community-based breeding programs are an option for genetic improvement of livestock in developing countries. This new approach has been tested with promising results in several places (e.g. with sheep and goats in Ethiopia, dairy goats in Mexico, llamas and alpacas in Bolivia and Peru, sheep in Argentina).

In Ethiopia, ICARDA and its partners designed and implemented CBBPs for several sheep and goat breeds representing different agro-ecologies and production systems. Three CBBP sites in Ethiopia (Bonga, Horro and Menz) were evaluated (in technical and socio-economic terms) and found to have had important outcomes and impacts. In general, there has been improvement in performance of the flock over the years. There have also been encouraging benefits—biological, organizational and economic—derived from CBBPs compared to non-participating communities.

Outcomes include:

- More than 18,000 people have directly benefited from the scheme (3200 households in 40 villages).
- “Best of stock” growing ram lambs/kids, previously sold and slaughtered (“negative selection”), are now kept to improve the breeding stock.
- There have been substantial genetic gains in the populations. For example, six months weight, the major selection trait in the CBBPs, increased over the years in all breeds.
- Farmers forming registered cooperatives to organize the breeding programs and purchase/sales of rams/bucks.
- The program trained eight PhDs (seven Ethiopians), nine MSc recipients (eight Ethiopian) hundreds of NARS and extension staff and thousands of farmers/pastoralists.

Impacts include:

- Sheep production has become a main line of business for many community members in Ethiopia.
- Increased income from sheep production (since CBBP inception in 2010, an average increase of 20 percent) and increased mutton consumption (now an average of three sheep slaughtered per family per year compared to one sheep at the project start) directly linked to CBBP production.
- High demand for breeding rams from neighboring communities, other government programs and NGOs in all sites, provides the base for specific business models around production of breeding sires and semen for artificial insemination.
- Most of the participating households in Menz (one of the CBBP sites) graduated from the government-run safety net program that meets short-term food needs through emergency relief. They now use income from sheep sales to buy food.
- The cooperatives have been able to build capital for buying rams and other investments, building on the initial revolving funds supported by the project (for example, the Bonga cooperative has capital of around USD60,000).

These guidelines were first prepared in 2011 to address the lack of generic guidance on designing and implementing of community-based breeding. Substantial experience has now been accumulated in CBBPs and it is imperative to update the guidelines and strengthen them with additional information related to the use of genomics in CBBPs and methodologies for dissemination (out scaling) of improved genetics. Though based on the Ethiopian experience, the modalities highlighted in the guidelines generally apply to similar situations where community-based breeding is an option. As community-based breeding program is a novel approach and dynamic by nature, the guidelines will have to be periodically refined and updated. They should not be viewed as a complete and final piece of work.

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Annex 1. Community-based smallholder sheep/ goat breed improvement in Ethiopia–data recording template

Lamb/kid Template

Farmer	Lamb/ kid ID	Dam ID	Sire ID	Litter size	Birth date	Sex	Birth weight	Coat Color	Weight at three months	Date	Weight at six months	Date	Yearling weight	Date	GFW	Tail

Ewe/doe Template

Farmer	Ewe/doe ID	Name/Special identifier	Coat Color	Sire ID	Mating date	Parity	Litter size	Litter weight	PP Wt	WWt

Ewe/doe Card (to be kept in each household)

Ewe/doe ID No./Name: ___________________ Dam's ID/Name: _________________________

Coat color: _________________________ Sire's ID/Name: _________________________

Birth date: _________________________ Owner's name: __________________________

	Parity number								
	1	2	3	4	5	6	7	8	9
Mating date									
Sire's ID No./Name									
Lambing/kiding date									
Litter size									
Lamb's/kid's ID & sex (Lamb/kid 1)									
Lamb's/kid's ID & sex (Lamb/kid 2)									
Litter weight at birth									
Ewe/doe post-partum weight									
Litter weight at weaning									
Ewe/doe weight at weaning of lambs/kids									
Number of lambs/kids weaned									

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