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REPORT OF THE USAID DESIGN TEAM FOR THE DEVELOPMENT OF THE NATIONAL BUREAU OF ANIMAL GENETIC RESOURCES FOR CONSERVATION, EVALUATION, UTILIZATION AND MANAGEMENT OF INDIGENOUS LIVESTOCK GENETICS RESOURCES OF INDIA

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1. PROJECT DESCRIPTION

The prudent management of animal genetic resources is essential for the continued improvement of animal production. Formal programs for plant genetics resources conservation, exchange and utilization have been in operation at national and international levels for some time, and have made valuable contributions to the success of crop improvement. However, until recently, limited attention has been given to animal genetic resources, and in fact no formal national or international program on animal genetic resources conservation has been fully implemented to date. The need for such programs is urgent. Livestock and poultry production are integral parts of most agricultural ecosystems of the world, contributing importantly to draft power, nutrient recycling, human nutrition, economic development and, not infrequently, to human culture. Animal genetic resources are being lost due to human population increase and loss of grazing resources and to cross breeding or breed substitution.

India has an exceptionally rich diversity of animal genetic resources, and has created a National Bureau of Animal Genetic Resources to coordinate the characterization, conservation and utilization of this genetic diversity. This project proposes to strengthen that organization and to assist with the full implementation of its mandate, for the benefit of India and for other countries where Indian animal genetic resources can make a contribution. Implementation of the program is projected over a seven year period.

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2. ACKNOWLEDGEMENT

The USAID Design Team on Animal Genetics Resources wishes to express its sincere appreciation to the many individuals in both the public and private sector whom it had the privilege of meeting and the opportunity of discussing and viewing animal production and management programs and systems. We were greatly impressed by the interest and dedication of professionals and producers in their livestock and in their work. While the names of all of the individuals are too numerous to mention here, we are nevertheless indebted to each of them individually for sharing their insights with us.

It was particularly important to the mission to have met also at the Indian Council for Agricultural Research (ICAR) with the Director General, Dr. V.L. Chopra; the Deputy Director General (Animal Sciences) Dr. S.C.Jain; and Dr. R.S. Rana, Director of the National Bureau for Plant Genetic Resources to whom we are grateful for the time given to us from their busy schedules and for their guidance to the Team. We are especially indebted to Dr. D.S. Balain, Director of the National Bureau for Animal Genetic Resources (NBAGR) for organizing the field visits and accompanying the Team throughout the period of the mission.

Finally, we wish to express our appreciation to Winrock International and its staff both in the United States and in India for giving us the opportunity to participate in this important study. Livestock genetic resources conservation is a relatively new activity. There are no fully functioning models from which to draw experience. By taking the decision to embark on this program, the Government of India will make a significant contribution to other initiatives for the conservation and utilization of animal genetic resources and we are pleased to have collaborated with Indian scientists in developing the work of the National Bureau for Animal Genetic Resources.

3. EXECUTIVE SUMMARY AND RECOMMENDATIONS

India has a rich diversity of cattle, buffalo, sheep and goat breeds which are important not only to the people of India but have contributed significantly to livestock production programs in many other tropical and subtropical climatic areas of the world. The crossing of more productive breeds of cattle from temperate climatic zones with highly adapted indigenous breeds has resulted in reduction in population size in some of the latter. The future need for adapted genotypes of cattle, buffalo, sheep and goats to contribute to new composite breeds in combination with more productive breeds from temperate climatic zones for use in India and in other tropical and subtropical climatic zones, is a compelling argument for a comprehensive program of identification, evaluation, conservation and improvement of indigenous Indian breeds of these four species. Other species may receive attention when programs for these species have been established.

The Indian Council of Agricultural Research (ICAR) has established a National Bureau of Animal Genetic Resources (NBAGR). The mandate is to identify, evaluate, conserve and improve indigenous breeds of cattle, buffalo, sheep and goats to provide the genetic diversity to meet future needs of India and of other tropical and subtropical climatic zones. These unique and valuable resources can make major contributions to maintaining genetic diversity and should be conserved. There is an international interest in their conservation as well as a potential for the marketing of animals, semen and embryos to increase foreign exchange earnings.

Because the NBAGR has neither the physical plant nor livestock resources directly under its control required to discharge its mandate, it must develop collaborative efforts with other Institutions of ICAR, State Agricultural Universities, Ministry of Agriculture Farms, State Farms, Military Farms and Private Sector Farms. Co-ordinating leadership for identification, evaluation, conservation and improvement of

indigenous breeds should be provided by a highly qualified staff of animal breeders/quantitative geneticists in NBAGR. To be successful, this approach must have full support at the highest policy levels of ICAR and at the policy and scientist level of all cooperating institutions and organizations. The role of NBAGR in this comprehensive program is to provide national coordinating leadership.

The cooperative efforts should be conducted under a Master Memorandum of Understanding (MMOU) between NBAGR and cooperating institutions or organizations with Memoranda of Understanding (MOU) developed as needed to cover efforts of each project. The contributions of each cooperating institution and organization to this comprehensive program should be by cooperating scientists who serve as project leaders for each project on each species at each cooperating institution. Protocols for data collection should be developed under the leadership of NBAGR scientists and project leaders should have responsibility for collection and transmittal of data to NBAGR Headquarters. NBAGR will have responsibility for developing and monitoring a central data bank for all projects.

NBAGR should provide funds to the cooperating institutions at the level required to cover the added costs of data collection and of other costs associated with NBAGR project requirements. Also, NBAGR should have responsibility for the cryogenic preservation of semen or embryos, consistent with the needs of the comprehensive program. The staff of NBAGR should include highly qualified scientists in the following areas :

(1) Animal breeding and quantitative genetics to provide leadership for planning, organizing and executing programs of identification, evaluation, conservation and improvement of indigenous breeds of cattle, buffalo, sheep and goats.

(2) Molecular and biochemical genetics to provide characterization at the genomic level.

(3) Data processing and management, to develop and maintain data banks of breed descriptors, performance data, genetic

characters, blood parameters, etc. and

(4) Cryogenic preservation.

In addition to the staff located at NBAGR Headquarters at Karnal, at least two quantitative geneticists should be located in the south of India to collaborate with scientists at cooperating institutions in this geographic area.

The Director, NBAGR should be given authority to recruit staff with the high scientific qualifications required to provide national co-ordinating leadership for the NBAGR Programs. Recruitment and training of a highly qualified scientific staff should begin immediately.

If the NBAGR Program is funded by external sources, a Project Coordinator with a strong background in animal breeding and quantitative genetics should be provided by the donor agency when funding is committed. Further, consultants in the areas of (1) animal breeding and quantitative genetics, (2) data processing and management, (3) cryogenic preservation and (4) molecular and biochemical genetics should be used, particularly in the early stages of the program and when needed, as determined jointly by the Project Coordinator and by the Director, NBAGR.

External funding will be required to provide experienced highly qualified quantitative geneticists needed as consultants, for specialized training of (especially young) Indian scientists and for the acquisition of specialized equipment and supplies.

Two Advisory Bodies should be established to assist the NBAGR in accomplishing its Mandate.

1) <u>Policy Advisory Board</u>

The Policy Advisory Board should be appointed by, and chaired by, the Director General, ICAR and should be limited to 15 members who function at policy making levels of GOI. The role of the Policy Advisory Board should be to make recommendations to the Minister of Agriculture, GOI on policies needed to enhance the effectiveness of NBAGR in discharging its Mandate. Policies recommended should

encourage collaboration between NBAGR scientists and scientists of cooperating institutions and should develop policies on international exchange of germplasm. The Director, NBAGR should serve as Executive Secretary of the NBAGR.

2) Technical Advisory Committee

The Technical Advisory Committee should be chaired by the Director, NBAGR and should function primarily on a subcommittee basis organized by species, i.e., (1) cattle, (2) buffalo, (3) sheep and (4) goats. Chairmen of species subcommittees should be appointed by the Chairman of the Technical Advisory Committee. Membership to the Technical Advisory Committee should be scientists from NBAGR and scientists serving as project leaders from cooperating institutions. The Technical Advisory Committee should have two primary functions :

(a) Make recommendations to the Policy Advisory Board on policy and program changes that may be needed to accomplish the mandate of NBAGR in providing leadership for a National Animal Genetic Resources Management Program.

(b) Provide a forum for exchange of ideas and information on all technical considerations relating to planning, organizing and accomplishing the Mandate of the NBAGR.

Specific Recommendations:

1. The NBAGR should accomplish its mandate by providing coordinating leadership through cooperative programs with Species Institutes of ICAR. Directorates of ICAR, and at Farms of State Agricultural Universities, Ministry of Agriculture, State, Military and the Private Sector. The NBAGR should achieve its mandate by providing coordinating national leadership for all elements of a comprehensive animal genetic resources management program.

2. It is recommended that a comprehensive program of characterization, evaluation, utilization and selection of indigenous breeds of cattle, buffalo, sheep and goats be implemented immediately at sites similar to those where each breed evolved. This comprehensive program of animal genetic resources management under the coordinating leadership of the NBAGR should be integrated into a National Animal Breeding and Genetic Research Program.

3. It is recommended that the Institute of Animal Genetics and the National Bureau of Animal Genetic Resources be merged into a single unit (NBAGR) within ICAR.

4. It is recommended that the NBAGR (cum Institute) give high priority to accurate characterization, in terms of performance potential for bioeconomic traits and at the gene level, of the major indigenous breeds of cattle, buffalo, sheep and goats.

5. It is recommended that a Policy Advisory Board be established with Director General, ICAR as Chairman to make recommendations to the Minister of Agriculture on policies needed to enhance accomplishment of mandate by NBAGR. It is recommended further that a Technical Advisory Committee be established with the Director, NBAGR as Chairman. The Technical Advisory Committee should provide a forum for exchange of ideas and information among cooperating scientists relevant to NBAGR Programs, and should make recommendations to the Policy Advisory Board on policy and program changes needed to enhance achievement of NBAGR objectives.

6. It is recommended that the NBAGR should prepare Memoranda of Understanding to be executed with each of the collaborating Institutions specifying in each the terms under which

cooperative programs would be carried out including those relating to proprietary rights and management of data and information.

7. It is recommended that NBAGR should plan initially for a staff consisting of about 15 scientists: 6 trained in quantitative genetics and breeding, 4 in population genetics and genetic characterization and two each in data processing and in physiology of gamete and zygote production and storage. Each scientist position will require one or more technical support positions. In addition, there should be a professional position assigned to preparation and dissemination of information.

8. It is recommended that provision be made for 12 person-months of expert consultations in addition to the Project Coordinator, for the first year of the program, and 8 person-months for each of the subsequent three years of the program.

9. It is recommended that the program provide for 3 post-doctoral traineeships per year of 6 months duration on average (range 3 to 9 months) for each of the first two years, and two per year thereafter. It is further recommended that there be either 2 pre-doctoral fellowships of 3.5 years each in the area of quantitative genetics and animal breeding, beginning in the first year, or two long-term post-doctoral traineeships in this area.

10. The team recommends that the NBAGR develop adequate office and laboratory facilities initially for 20 scientists, provide space for data processing with space to meet needs for cryogenic storage of semen and embryos with a duplicate cryogenic storage capability at a second location.

11. It is recommended that external funds be made available to the project to enable the contracting of necessary specialists from abroad, for acquisition of materials and equipment and for special training programs abroad.

12. It is recommended that ICAR explore alternative procedures giving greater latitude to Institute and Bureau Directors in recruitment of their key scientific staff.

4. INTRODUCTION AND RATIONALE

4.1 Introduction

The Government of India has a long history of plant exploration, conservation, evaluation and utilization. Beginning with programs in the IARI in the 1940s, the Plant Exploration division later emerged in 1976 to become the National Bureau for Plant Genetic Resources. India's growing concern for the conservation and utilization of its genetic wealth caused it to take further steps to assure that the large animal populations were adequately inventoried, characterized and conserved. It thus created the National Bureau for Animal Genetic Resources (NBAGR) in 1984 with the objectives of "identification, evaluation, conservation, and utilization of the valuable animal genetic resources of the country." The National Institute of Animal Genetics (NIAG) was also established in 1984 to "provide scientific support to the National Bureau of Animal genetic Resources and to take up research work of very fundamental nature not ordinarily taken up at the existing ICAR Institutes and Agricultural Universities."

A number of animal species specific institutes were also established whose mission in general was to carry out research and development work related to the species for which they had responsibility. Thus, there are specialized institutes for sheep and wool; for goats; for buffalo; for poultry; for camels and a directorate for cattle breeding. For example, the mandate of the Central Institute for Research on Goats (CIRG) is to "undertake

research for developing superior strains of goats for high productivity of meat, milk, and fiber; to develop packages of practices for feeding, management, and disease control; and to study various aspects of processing of goat meat, milk and pashmina." The other Institutes have similar mandates.

It can be seen that the work of the Bureau (NBAGR) was designed to be complementary to the functions of the institutes for animal improvement and management. One of the main functions of the Bureau, the conservation of animal genetic resources, will require a great deal of coordination with the species specific centers, but the Bureau will also manage its own activity related to dispersed herds and flocks.

The Bureau is still in the early stages of organizing its programs, developing its staff, designing its strategy and acquiring the necessary tools and equipment to execute its programs. The urgency now is to hasten the pace of implementation of the Bureau programs. This is a formidable task and one which will require considerable leadership from Bureau scientists.

4.2 Rationale for an Organized Program

The genetic diversity among livestock species of India is vast. Conservation of this diversity is necessary to ensure that adequate variation will be maintained to facilitate adjustment to future needs of livestock production ecosystems. These may change due to changes in production resource base for food and fiber animals and in market requirements for animal products.

The cattle genetic resources of India have contributed significantly to the development of beef or dairy production systems in tropical and subtropical regions of many countries of South and Central America, subtropical and some temperate climate zones of the United States, and tropical and subtropical zones of Australia. Further, Indian cattle have contributed useful germplasm to Southeast Asia. Germplasm from Indian buffalo have made significant contributions to many tropical and subtropical

climatic zones, and Indian goat germplasm has contributed to goat production in many countries of the world.

Thus, the interest in conserving and improving indigenous breeds of tropically adapted livestock genetic resources of India is global and should receive high priority by the Government of India (GOI) and by other national and international agencies and organizations. At present, cattle, buffalo, sheep and goats receive primary attention in the National Bureau of Animal Genetic Resources (NBAGR) Programs.

The replacement of highly adapted indigenous pure breeds of cattle that have relatively low milk production potential with crosses of highly productive breeds from temperate climatic zones has resulted in reduction in numbers of animals in some of the indigenous breeds. Thus, conservation and improvement measures for these breeds is needed to provide the flexibility required for most effective future utilization of this resource in organized breeding programs. This includes programs in India and in other tropical and subtropical climatic zones.

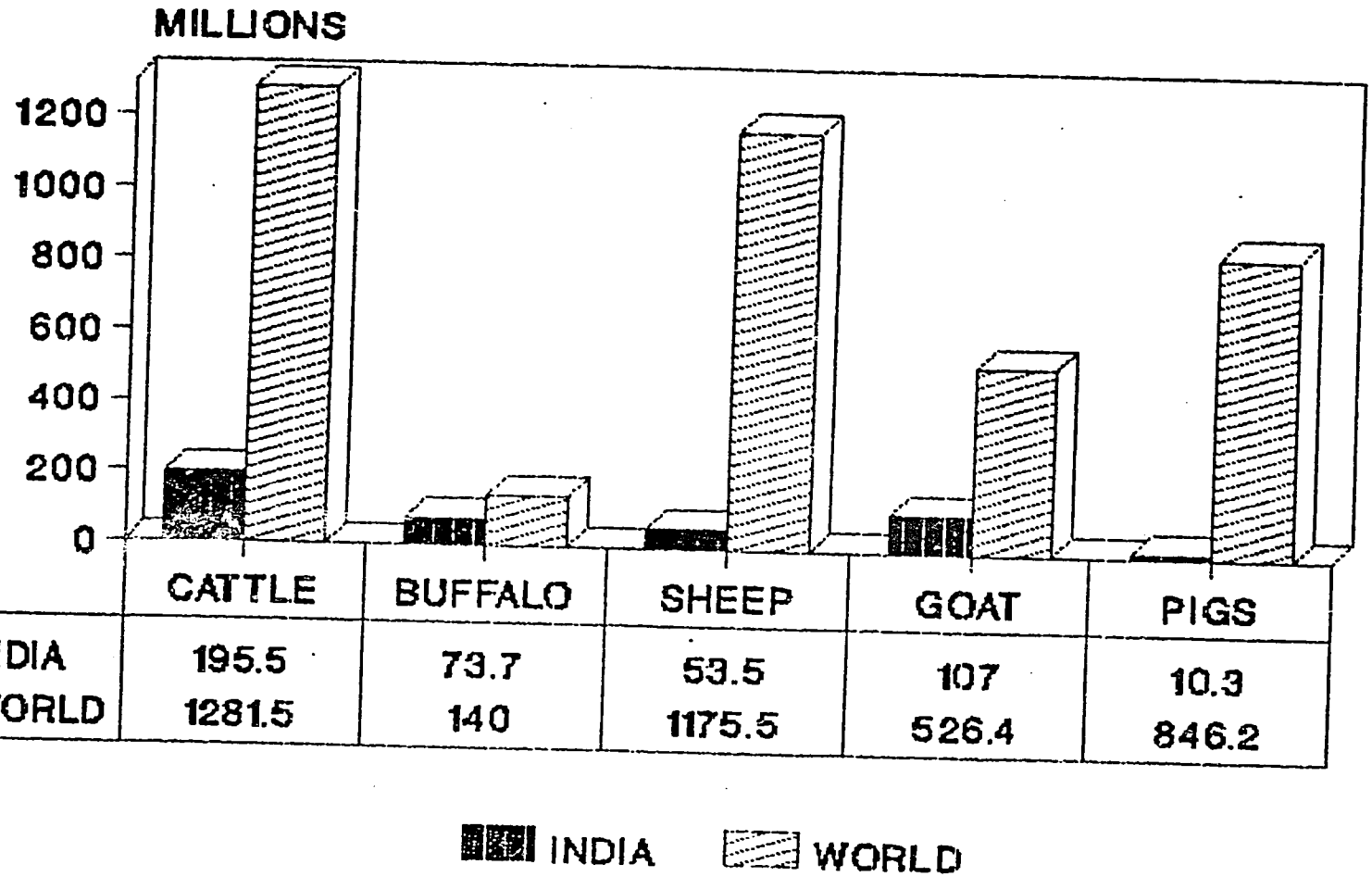
The development of new composite breeds of cattle combining the adaptability to stressful environments of indigenous breeds with the higher production capability of breeds from temperature climates will be facilitated if improved pure breeds of tropically adapted Indian cattle are available.

The livestock population of India relative to the global inventory is presented in **Figure 1.**

5. CURRENT STATUS OF THE NBAGR PROGRAMS

Currently, the Bureau is located in the facilities of the National Dairy Research Institute at Karnal. Some basic facilities required for the operations of the Bureau have been established. As they now stand, these are inadequate for the proper functioning of the Bureau. Additionally, some program functions have begun which include the assembly of information by the Data Management Center on some livestock and poultry populations. The Bureau has developed procedures for conducting

Figure-1: LIVESTOCK POPULATION INDIA VS WORLD (FAO 1989)



	CATTLE	BUFFALO	SHEEP	GOAT	PIGS
INDIA	195.5	73.7	53.5	107	10.3
WORLD	1281.5	140	1175.5	526.4	846.2

surveys and the collection of information and data in the native breeding tracts including information about the systems under which animals are maintained. Although protocols have been designed for in situ and ex situ conservation of different types and breeds of livestock, these have not yet been fully implemented.

6. OBJECTIVES OF THE DESIGN TEAM

The objectives of the Design Team were:

1. to assess the kinds and types of genetic resources to be conserved including the rare and endangered breeds and species for priority attention. Other breeds and types for subsequent attention should be considered.
2. to review plans for animal improvement work and ecosystem integration.
3. to asses existing programs of the Bureau and related institutions with regard to staffing and facility requirements to carry out the Bureau mission.
4. to determine the priority research areas in respect to conservation/preservation.
5. to review plans for facility development and equipment requirements of the Central Office/Laboratory and regional programs.
6. to review the role of various Institutes, Universities, Colleges, and other public and private sector organizations in carrying out the work of the Bureau.
7. to determine staffing and training needs.
8. to review import and export aspects of animal germplasm management.

The Design Team has made a number of additional observations related to animal genetic resources management. These relate particularly to the urgent need to establish breed and program priorities, to assemble the requisite qualified staff, to define and begin training programs for different level personnel and to develop working agreements with collaborating institutions.

7. PROPOSED PROGRAM

7.1 Functions of the NBAGR

It should be mutually agreed and understood by participating agencies that close collaboration of Species Institutes of ICAR, Directorates of ICAR, State Agricultural Universities, Ministry of Agriculture Farms, State Farms, Military Farms and Private Sector Farms with the National Bureau of Animal Genetic Resources (NBAGR) is essential for planning, organizing and executing an effective program of animal germplasm conservation (&animal genetic resources management). This program should be integrated into an All Indian National Livestock Breeding and Genetics Research and Improvement Program.

The NBAGR in this national program is expected to discharge its mandate primarily by providing coordinating leadership at all stages of the process. Thus, the highest level of scientific leadership is required by NBAGR quantitative geneticists and animal breeders who provide this coordinating leadership. The NBAGR should be funded at the level required to support the added costs needed to evaluate, maintain, conserve and improve the germplasm at each site operated by the cooperating institutions/organizations identified as collaborators.

The essential coordinating leadership responsibilities of the NBAGR in this process should include, but not necessarily be limited to, the following :

1) Develop a **Master Memorandum of Understanding (MMOU)** that is applicable to cover joint efforts with all organizational units included in collaborative efforts on animal genetic resources conservation, characterization and utilization; hereafter referred to as an **Animal Genetic Resources Management Program (AGRMP)**. Specific projects should be covered or described in individual **Memoranda of Understanding (MOU's)**. MMOUs and MOUs will be as mutually agreed to between NBAGR and collaborating institutions.

2) Identify and characterize the breeds/groups existing within each species. Characterization should be for bio-economic traits and for sufficient genetic markers that a profile for each distinct breed can be established. Develop protocols for data collection including breed descriptors, performance traits, blood for genetic analyses, etc. This may include training of teams for data collection for each project at each location.

3) Organize collaborative efforts with cooperating institutions such that an AGRMP is integrated into a comprehensive animal breeding and genetics research program for all species included in the NBAGR Program.

4) Identify breeds or populations of each species that are candidates for efforts on characterization/evaluation and implement characterization programs based on assigned priorities.

5) Develop strategies for the most effective utilization of breeds included in the NBAGR Program.

6) Design a comprehensive program to characterize/evaluate all candidate breeds for the NBAGR Program and identify cooperating institutions and scientists for each breed to be characterized/evaluated by NBAGR. Each effort should be organized as a project.

7) Once pure breeds of each species are identified for conservation and improvement, develop selection criteria and procedures for continued improvement toward the selection goal identified for the breed in the production environment most favoured by economic factors. Establish on line data transmission from project site to NBAGR data bank.

8) Provide funding to the cooperating institutions in the amounts required to support the added costs of the NBAGR

conservation element for which the breed is maintained and improved. For example, this may include performance and breed descriptors, data collection, semen collection, blood collection, etc.

9) Develop and maintain data banks of morphological or anatomical breed descriptors, performance traits and relevant genetic markers, consistent with the requirements of an organized AGRMP and for other purposes as needed.

10) Provide cryogenic preservation of semen and (or) embryos as appropriate on samples of animals from all breeds included in the AGRMP. Conserve semen from a sample of sires for each generation (5-6 year intervals for cattle) from active breeding populations, to provide an estimate of genetic change over time and to provide characterized genetic material which may be of use if breeding goals change.

11) Using appropriate biochemical and molecular techniques, augment characterization at the performance trait level with characterization at the genome level as a basis for estimating "genetic distance" among breeds. This activity will provide information relevant to making decisions on what breeds may be merged or combined because they are not different genetically, and information on genetic distance among breeds relevant to estimating potential heterosis from specific breed crosses.

12) Provide information on parental identification (sire and dam) using "DNA fingerprinting" as this technique becomes feasible, as a basis for genetic analyses of data and for estimating inbreeding.

13) Develop breeding strategies in all conserved populations so that rate of increase in inbreeding will not exceed .5% per generation.

14) Develop programs of dissemination or releases of improved, conserved germplasm to private sector interests of India that have an approved plan for use of such germplasm.

15) Make improved germplasm available, on a mutually agreeable basis, to other countries that have a plan for use of such germplasm based on scientific principles.

16) Work with animal health regulatory authorities of India to develop an animal health program of germplasm from conserved breeds of each species that is adequate to facilitate their international movement and potential commercial value on a global basis.

17) Develop mutually agreeable binational efforts for exchange of improved, conserved germplasm with other countries that have animal germplasm that shows promise of contributing to animal production efficiency in India.

18) Participate in international programs of animal genetic resources management that may be organized under FAO or other international organizations consistent with the Mandate of NBAGR. Initiatives now suggest that the FAO may develop an international program of animal genetic resources management similar in function to the International Board for Plant Genetic Resources. Because of its great diversity of cattle, buffalo, sheep and goat genetic resources with adaptability to tropical and subtropical conditions, India would be expected to play a major role in international animal genetic resources management programs.

The activities listed requiring NBAGR coordinating leadership are consistent with the team's interpretation of the mandate given to NBAGR by ICAR in which NBAGR is expected to provide leadership for a comprehensive animal genetic resources management program.

If collaboration is to be effective, there must be mutual agreement between, and committed support by, all participants in the program. Because the organizations/institutions that are potential collaborators with NBAGR in the area of evaluating, conserving and utilizing indigenous livestock breeds of India have control of the physical plant and livestock resources, they must be committed fully to the success of NBAGR Programs. There cannot be expectation of success of a conservation program for useful indigenous livestock breeds of India unless it is given high priority at the highest policy making levels of the cooperating institutions/organizations, and by the Director General and the Deputy Director General for Animal Sciences, Indian Council of Agricultural Research.

Recommendation : The NBAGR should accomplish its mandate by providing coordinating leadership through cooperative programs with Species Institutes of ICAR, Directorates of ICAR, and at Farms of State Agricultural Universities, Ministry of Agriculture, State, Military and the Private Sector. The NBAGR should achieve its mandate by providing coordinating national leadership for all elements of a comprehensive animal genetic resources management program.

7.2 Program of NBAGR

The Government of India through the Indian Council of Agricultural Research (ICAR), has established a National Bureau of Animal Genetic Resources (NBAGR) with a mandate to conserve and improve indigenous breeds of Indian livestock. The goal is to meet current and future needs for genetic diversity of India and other tropical and subtropical regions of the world.

The overall objective of NBAGR should be the conservation,

improvement and utilization of livestock genetic resources of India, to ensure maximum long term efficiency of production for diverse and changing Indian livestock production and marketing systems.

A program to achieve this broad objective requires :

1) Characterization/evaluation and the development of procedures for utilization and improvement of diverse genotypes which collectively are adapted to a broad range of Indian animal production ecosystems, and

2) In situ and/or cryogenic preservation of potentially useful livestock germplasm that may be in danger of extinction.

An NBAGR program to attain this broad objective should include the following :

7.2.1 Characterization of Livestock Ecosystems and Germplasm

It is recognized that the NBAGR has neither the livestock populations nor the physical plant resources required to independently conduct an organized program of livestock germplasm evaluation. Livestock and physical plant resources to meet this requirement are available in other units of the Indian Council of Agricultural Research (ICAR), at State Agricultural Universities, at Ministry of Agriculture farms, at Military farms, at State farms and on Private farms. Thus, this essential element of the mandate of NBAGR must be accomplished in collaboration with scientists at these cooperating institutions through Memoranda of Understanding (MOU's).

Conservation of livestock genetic resources should be fully integrated with a comprehensive program aimed at genetic improvement of livestock. Recognition of important ecosystem differences in production resources and in market requirements is essential to define the genetic objectives for optimum adaptation for all livestock species included in the NBAGR program. Optimum adaptation is defined as maximum bio-economic efficiency in the ecosystem of interest.

High priority should be given to evaluation of sustainable

production capabilities of major ecosystems and characterization of Indian livestock genetic resources. This information is required for developing highly adapted live populations and to choose selected stocks for cryogenic or live population conservation and improvement.

It is recognized that genetic diversity is more important and easier to maintain for extensively managed cattle, buffalo, sheep and goats than for poultry, swine or intensively managed dairy cattle. The relatively low life-cycle biological efficiency of animals kept for meat, fiber or draft makes them more dependent upon adaptation to a wide range of climatic conditions and less favourable nutritive environments than is the case for the more intensively managed species.

Indian participation in global germplasm evaluation efforts through FAO or on a binational basis with other countries may be useful in both the characterization of indigenous breeds and for the identification of the most promising genetic material for possible importation for use in combination with indigenous breeds to develop new composite breeds.

7.2.2 Maintaining Diverse Economically Viable Populations

Decisions on populations (breeds) to be conserved and improved should be based on results of organized programs of characterization and evaluation in the environment most favoured by economic factors.

The diverse and changing nature of agricultural development in India favours management of animal genetic resources primarily as economically viable populations at collaborating institutions. This may need to be supplemented by either live or cryogenic preservation of selected endangered stocks that possess gene(s) of potential value for future use. Inability to predict long-term changes in production environments and in market requirements suggests emphasis on continuous selection for optimum adaptation in each livestock species, as a method of maintaining adequate genetic diversity. This approach requires

initial evaluation/characterization of existing stocks, the development of breeding systems for their optimal use; and continuing selection within breeds for optimum adaptation within each major ecosystem.

7.2.3 Conservation of Unique Endangered Animal Germplasm

Composite populations provide an efficient approach for conserving genes that have a major effect (e.g., resistance to specific diseases, etc.) for possible future use by transfer into economically viable populations. Where conservation of single genes with major effects is important, rather than conserving the integrated genome, composite populations can retain, in a single population, a large number of genes ("gene pool") for possible future use.

Even though *in situ* management of economically viable populations is suggested as the primary strategy for conserving breeds of Indian livestock species, this approach should be supplemented by organized cryogenic storage of semen and/or embryos, as appropriate, from specific genetic stocks. Cryogenic storage in combination with "gene pool" or composite populations of live animals may be used effectively to preserve genes from stocks that are not currently economically viable and are in danger of extinction, but which possess unique gene(s) with major effects on bio-economic trait(s) that may be useful in the future. Also, genes of inadequately characterized genetic stocks that are in immediate danger of extinction, but judged potentially useful in some existing or future production and marketing ecosystem, should be conserved until more adequate evaluations are made. For most such populations, collection and storage of semen samples from 25 or more males should be sufficient. For populations judged of special potential for future breeding work, storage of embryos may be justified. A supply of 200 embryos should be adequate to reconstitute a viable population.

7.2.4 Breeding Strategies to Conserve and Improve Pure Breeds

A large number of indigenous breeds of cattle, buffalo, sheep and goats have been identified for evaluation, characterization, conservation and improvement. More may be identified in the future.

In addition to maintaining genetic diversity among breeds, by improving them in the ecosystem where they have optimum adaptation, it is essential to develop breeding strategies that will maintain genetic variation within breeds by avoidance of high levels of inbreeding. Inbreeding depression is of particular importance for fitness traits (e.g., fecundity and survival). Further, a program of genetic improvement focused on achieving optimum adaptation in the production environment in which the breed was developed is recommended. Maximum bio-economic efficiency or optimum adaptation are defined as more output of product per unit of input in the environment that is most favoured by economic factors. Selection for such efficiency should result in the inclusion of fitness traits in the selection criteria. In addition to reducing performance, particularly for fitness traits, inbreeding results in reduced effectiveness of intra population selection because of reduced genetic variation.

Inbreeding can be kept at a low rate by the use of 25 or more sires in each generation. The use of 25 sires per generation should keep inbreeding at a rate of approximately .5% per generation. For cattle, generation interval may average 5-6 years. Thus, over a period of 10 generations (50-60 years), inbreeding in the population would be expected to increase by about 5%.

Scientific staff (e.g., quantitative geneticists) of the NBAGR must be active participants in the identification of sites where each indigenous breed is evaluated, and should provide leadership in the development and execution of breeding strategies to maintain and improve the breeds identified for conservation. Sites for each breed should represent the climatic and nutritive environment in which the breed was developed and is

expected to be used. On farms of ICAR, State Agricultural Universities and Central and State Ministries of Agriculture, resident scientists are expected to serve as project leaders with close collaboration of NBAGR scientists. At Military farms and at private farms where resident scientific staff are not generally located, NBAGR scientists should serve as project leaders.

For each situation, careful attention should be given to the development of selection criteria and procedures and should focus on improving productive efficiency. Data collected should include those traits for which the breed is to be characterized and traits that are included as selection criteria in a genetic improvement program.

7.2.5 Data Management

NBAGR scientists should provide leadership for developing protocols and training of teams for data collection for all breeds (populations) being conserved, for the efficient transmittal of data to NBAGR offices and for entering data on centrally maintained data banks. Project leaders should have responsibility for editing data before transmittal to NBAGR data banks. For each population being evaluated or conserved, project leaders should ensure that data are collected consistent with established protocols.

Project leaders should have primary responsibility for analyses of data and for publication of results. However, collaborating NBAGR scientists should contribute to the planning and organization of each effort and are expected to make a contribution to the process sufficient to earn co-authorship. In cases where project leaders fail to take leadership for analyses of these data and publication of results within a reasonable period of time (e.g., 3 years) after the collaborators (NBAGR scientists and Project Leader) have mutually agreed that results should be published, NBAGR scientists may assume responsibility for analyses of data and publication of results. The rights of

project leaders to proceed with analyses of data and publication of results for which they are responsible should not be pre-empted by NBAGR scientists. However, the aforementioned process is essential to ensure timely publication of results when the project leader delays the process.

When mutually agreed to by project leaders and by collaborating NBAGR scientists, data from more than one project may be pooled for analyses and the results published in appropriate scientific journals. Generally, this is expected to be under the leadership of a collaborating NBAGR scientist. However, a project leader may assume responsibility for analyses of data pooled from different projects and publication of results if it is more appropriate and is mutually agreed to by the scientists involved.

NBAGR scientists should assume responsibility for maintenance of data banks, with appropriate backup, at NBAGR Headquarters. NBAGR scientists will be expected to provide summaries of results to meet project management and other requirements (annual reports, etc.) on a timely basis. These summaries are not produced for publication in scientific journals and should be managed in a manner so that the publication rights of the project leader are not pre-empted.

Analysis of data and publication of results from Military farms and from private farms where NBAGR scientists may function as project leaders should be under the leadership of NBAGR scientists who function as project leaders.

Recommendation : It is recommended that a comprehensive program of characterization, evaluation, utilization and selection of indigenous breeds of cattle, buffalo, sheep and goats be implemented immediately at sites similar to those where each breed evolved. This comprehensive program of animal genetic resources management under the coordinating leadership of the NBAGR should be integrated into a National Animal Breeding and Genetic Research Program.

7.3 Interrelationships of NBAGR and NIAG

7.3.1 Merger of NBAGR and NIAG

The Design Team has noted the existence of the National Bureau of Animal Genetic Resources (NBAGR) and National Institute of Animal Genetics (NIAG), under one Director, with a relatively small staff each. While the Bureau has functions in addition to research, e.g. inventory, preservation and coordination, it also has research needs. In view of the fact that the two organizations both relate to animal genetics, have a common location and a common Director, it is our view that a merger of the two into a single organization, NBAGR, would facilitate the development of an animal genetic resources conservation, management and utilization program in India. The present NIAG could become the Animal Genetics Research Group of the Bureau.

This suggestion does not in any way underestimate the importance of research in the broader field of animal genetics, nor does it rule out the possibility of re-establishing NIAG as a fully separate institute at some future date. Animal genetics research is being carried out at several ICAR Institutes and State Agricultural Universities, and this will undoubtedly continue. We note that the mandate of NIAG is "to provide scientific support to NBAGR and to take up research work of a very fundamental nature not ordinarily taken up at existing ICAR Institutes and Agricultural Universities". It is the opinion of the Design Team that the first of these is a higher priority activity at this time, i.e. the recommendation to merge NBAGR and NIAG is based on the importance of more complete development of an animal genetic resources conservation program, and the need for research directly related to this goal within NBAGR. In addition, the merger should reduce total administrative costs and, more importantly, increase the relevance of the research by scientists currently in the two organizations to genetic resources characterization and management. The merger would make more visible the high priority being accorded to development of an animal genetic resources management program for India, which

has been emphasized by many of the scientists and administrators whom we have met during our visit. In our view it would increase the probability of rapid and effective development of this program.

Recommendation: It is recommended that the National Institute of Animal Genetics and the National Bureau of Animal Genetic Resources be merged into a single unit (NBAGR) within ICAR.

7.3.2 Meeting Research Needs of NBAGR

With regard to specific research activities envisioned as meeting the needs of NBAGR, the overall focus should be on increasing the precision of genetic characterization of populations of Indian livestock breeds. There are numerous populations, of most if not all of the livestock species of interest, which are classified as different breeds. A major goal of the NBAGR program is to help ensure the maintenance of genetic diversity within each of the species, and it is the recommendation of the Design Team that *in situ* conservation, i.e. maintenance of breeding populations, be the primary approach. However, maintenance of breeding populations can be expensive, and it would be desirable to maintain the minimum number of populations needed to ensure retention of the range of genetic diversity currently available. This requires identification of those breeds/groups which are distinct.

Methods of characterizing populations include morphological and performance traits. The first of these can be evaluated using the descriptors prepared by NBAGR, and the second by standard performance recording and statistical methodologies used in animal breeding. Geography and breed history are also useful indicators of breed differences. However, these methods may not accurately identify unrecorded admixture of breeds, or identify breeds which are genetically very similar but differ only in some visible external trait, e.g. color. Therefore, to assist in characterization of populations and in the accurate determination

of genetic distances among them, more specific methods of identification of genetic differences are needed.

The particular methods to be used may vary with species and over time. Traditional methods include red cell antigens and protein polymorphisms identified by electrophoresis. More recently RFLP's, DNA fingerprinting and other molecular technologies have been added to the tools available. Choice of technology will depend on the genetic systems in which there are polymorphisms which differentiate breeds or groups of interest. For systems where more than one technology can be used, relative accuracy, cost, rapidity and simplicity will influence the choice of method. The importance of quick and inexpensive but accurate tests readily adapted to use with large numbers of samples cannot be overemphasized.

The team suggests that this is an area where one or more persons working in the area of genetic polymorphisms in populations, with livestock or at least with animal species, be invited in as consultants at an early stage (and perhaps at intervals during the program, since this is an area of rapidly evolving technology). Following identification of a small number of techniques which meet the criteria specified above, for the species of greatest interest, Bureau scientists could be sent for additional training in these technologies as needed.

With regard to specific technologies, the team notes that karyotyping appears not to be an approach which has been useful in distinguishing breeds, based on reports in the literature and on information presented to us during our tour of some Indian institutions. While molecular cytogenetic techniques may permit more precise discrimination among populations within a species, we believe that other approaches may be simpler and more useful. Thus this is an area where retraining of current NIAG scientists may be desirable.

As a general approach to integrating scientists from NBAGR and NIAG into an effective team on genetic resources conservation, management and utilization, it is suggested that

the scientists be brought together to work on a small number of well-defined problems. For example, some eight breeds of buffalo are described, and there is very probably some intermixing at the boundaries of the territories of these groups. To meet goals of NBAGR, it is important to know:

1) What are the differences among these breeds in:
   - o morphological characteristics (probably well documented now)
   - o body weights at birth and maturity under standard feeding conditions
   - o reproduction: age at puberty, calving interval, etc.
   - o milk production and composition
   - o draft power capacity
   - o genetic polymorphisms, e.g. transferrins, etc.

2) Do crosses among the different types occur, and can these be reliably identified by one or more of the above methods?

Answering these questions would permit development of a national conservation and utilization program for this species for the entire country. It could lead to expanded export of buffalo breeding stock. It would require collaboration among Bureau scientists and those of CIRB and several other institutions. It would also require collaboration among quantitative geneticists and those working on detection of genetic polymorphisms using immunogenetic, biochemical and molecular techniques. Properly organized, this could contribute to a team effort which would rapidly advance the goals of NBAGR.

Recommendation: It is recommended that the NBAGR (cum Institute) give high priority to accurate characterization, in terms of performance potential for bioeconomic traits and at the gene level, of the major indigenous breeds of cattle, buffalo, sheep and goats.

7.4 Advisory Bodies to The National Bureau of Animal Genetic Resources (NBAGR)

Two Advisory Bodies are recommended to help guide the activities of NBAGR : (1) Policy Advisory Board and (2) Technical Advisory Committee.

7.4.1 Policy Advisory Board

The primary role of the Policy Advisory Board is to make recommendations to the Minister of Agriculture, Government of India on policies needed to enhance the effectiveness of NBAGR in discharging its Mandate. Policies should ensure collaboration between NBAGR scientists and scientists of cooperating institutions. The Policy Advisory Board should help establish national policies for the import and export of animal germplasm included in NBAGR Programs. This should include animals, semen and embryos. In the event of disagreements between cooperating organizations or institutions, the Policy Advisory Board should make recommendations contributing to a resolution. The Policy Advisory Board should be limited to 15 members including the Chairman (Director General, ICAR) with membership (appointed by the Director General, ICAR) representing the following :

1) Directors of collaborating ICAR organizations.
2) Deputy Director General of Animal Sciences (ICAR).
3) Commissioner of Animal Husbandry, Ministry of Agriculture.
4) Director, National Bureau of Plant Genetic Resources.
5) Representatives of collaborating State Universities.
6) Representative of collaborating State Farms.
7) Representative of collaborating Military Farms.
8) Representative of the Livestock Industry of India.
9) Director, NBAGR who should serve as Executive Secretary of the Policy Advisory Board.

Terms of service on the Policy Advisory Board should be determined by the Director General, ICAR, but should be organized so that not more than one-third of the membership is replaced each year. Meetings of the Policy Advisory Board should be held

as needed but not less than annually. Meetings should be called by the Chairman, Policy Advisory Board.

7.4.2 Technical Advisory Committee

Chairman of the Technical Advisory Committee should be the Director, NBAGR. The Technical Advisory Committee should have two primary functions :

(1) Make recommendations to the Policy Advisory Board on policy and program changes that may be needed to enhance opportunities to accomplish the mission of the NBAGR in providing leadership for a National Animal Genetic Resources Management Program;

(2) Provide a forum for exchange of ideas and information on all technical considerations relating to planning, organizing and accomplishing the mandate of the NBAGR.

The Technical Advisory Committee should function primarily on a subcommittee basis organized by species (i.e., cattle, buffalo, sheep and goats). Chairmen of species subcommittees should be appointed by the Chairman of the Technical Advisory Committee. Membership of the Technical Advisory Committee should include, not less than five nor more than eight representatives of NBAGR scientists, and all Project Leaders whose efforts focus on NBAGR programs at collaborating institutions/organizations. NBAGR scientists whose efforts are not species oriented (e.g., data management, cryogenic preservation, etc.) may participate as needed in the activities of all subcommittees. The full Technical Advisory Committee should meet at least once each year and more often as needed at the call of the Chairman, Technical Advisory Committee. Other NBAGR and cooperating institution scientists (other than project leaders) may participate in meetings and workshops of species subcommittees as appropriate. When authorized by the Chairman of the Technical Advisory Committee, Chairmen of species oriented subcommittees may call meetings as needed to plan, organize and execute programs relating to that species consistent with the NBAGR Mandate. One of the early activities of the species subcommittees should be

the development of appropriate protocols for data collection, including breed descriptors, performance data, blood sampling, etc.

Recommendation : It is recommended that a Policy Advisory Board be established with Director General, ICAR as Chairman to make recommendations to the Minister of Agriculture on policies needed to enhance accomplishment of Mandate by NBAGR. It is recommended further that a Technical Advisory Committee be established with the Director, NBAGR as Chairman. The Technical Advisory Committee should provide a forum for exchange of ideas and information among cooperating scientists relevant to NBAGR Programs, and should make recommendations to the Policy Advisory Board on policy and program changes needed to enhance achievement of NBAGR objectives.

7.5 Mechanisms for Collaboration between the NBAGR and other Institutions

Many of the program activities of the Bureau will be carried out in collaboration with other institutions and agencies, including private individuals. It is not expected that the Bureau will maintain herds of animals for conservation of genetic resources. There are a number of well managed and cared for herds of cattle, buffalo, sheep and goats on which records are maintained and can be used for inventory, characterization and evaluation purposes even though these are not the primary purposes for which those herds and flocks are kept. They are located within government and state farms, universities, on military farms and some are in private herds and flocks. Nevertheless they represent an important genetic resource for *in situ* conservation and a ready source of data that needs to be assembled, analyzed, collated and made available to users.

In carrying out its functions, the Bureau will establish linkages with each of the institutions. To date these linkages have been somewhat informal. In some cases, the Institute were uncertain about how they were to carry out their role relating to

the Bureau and how additional costs related to Bureau programs would be met. In all probability, each case of collaboration will need to be negotiated separately. We visualize a range of mechanisms by which needed work could be carried out. For example, survey work may be done by an Institute, at Institute expense, on behalf of the Bureau. Data on herds normally maintained for herd improvement work and collected by the respective Institute or agency, could be readily made available to the Bureau at little or no extra cost. In other cases the Bureau may develop agreements with the organization for specific information to be collected or work to be carried out. An institute or agency may assign its own person(s) to liaize directly with the Bureau or conversely, the Bureau may assign its own staff to the respective organization. Whatever the relationship, such linkages should be formalized through the execution of Memoranda of Understanding which specify the responsibilities of each party.

7.6 Proprietary Rights to Data and Publication

An important issue which was raised by several of the Institute Directors concerned the matter of data ownership and publication rights. The Team believes that this is a very important issue and one in which the Bureau will have to establish a policy acceptable to the collaborating institutions. That policy should become an integral part of the MOU. While the proprietary rights of the originator must be respected, safeguards should be provided in the policy statement which would prevent the undue delay in making such data available for Bureau use.

Recommendation: It is recommended that the NBABR should prepare Memoranda of Understanding to be executed with each of the collaborating Institutions specifying in each the terms under which cooperative programs would be carried out including those relating to proprietary rights and management of data and information.

8. NBAGR OPERATIONS

8.1 Staffing. Professional Staff Needs of the NBAGR

Staffing needs for NBAGR as viewed by the design team include the following full time scientist positions, in addition to the Director. These include provision for the research functions discussed earlier.

8.1.1 Quantitative Genetics and Animal Breeding

It is recommended there be 6 positions in this area initially, 4 positions at headquarters and two at a regional station or stations. Individuals at headquarters would each be assigned primary responsibility for a species, i.e. for cattle, buffaloes, sheep and goats, although with the expectation that there would be collaboration among them on all of the work. Staff at regional stations would have responsibility for work with more than one species. As resources permit and as the program develops, the number could be usefully increased, to provide for specific expertise on other species, and, in some cases, on particular breeds or groups of breeds.

Functions of the scientists in these positions would include:

a) Collaboration with scientists and herd managers at units maintaining animal populations in the collection of performance and morphological data.

b) Summarization of these data from the perspective of population characterization, and preparation of publications in collaboration with the scientists providing the data.

c) Work with data processing scientists to develop data banks for ready retrieval of information on breeds of animals.

d) Collaboration in the development of breeding programs for the genetic improvement of the breeds and for the maintenance of genetic diversity between and (consistent with improvement goals) within populations of each species.

e) Collaboration with scientists working in the area of genetic polymorphisms in sampling populations for genetic studies, and in

the joint interpretation of genetic polymorphism and performance data.

f) Where cryopreservation of semen or embryos is indicated, sampling of the populations in question to ensure that the material stored is representative and of adequate sample size.

8.1.2 Data Management Systems

At least two professionals are recommended in the area of data processing and information systems management, supported by adequate technical staff for data input and system operation.

These persons would be responsible for acquisition and development of software to manage the large volume of morphological, performance and genetic data which the program would generate. They would work with other scientists in development of systems for ready retrieval of information and for preparation of reports appropriate to a range of audiences.

8.1.3 Genetic Polymorphisms

We recommend there be three or four scientists working in the area of breed characterization at the genetic level.

Primary responsibilities of these scientists would be to characterize different populations at the gene or DNA level, establish bases for breed identity and correlate these with morphological and performance traits, assess genetic distances between breeds, and monitor breed purity. Portions of the work would obviously involve collaboration with quantitative geneticists and data bank managers. Research on development of new methods of population characterization would also be a part of the responsibilities.

Scientists in this group would generally be oriented to laboratory analyses, but at least one of the group should have a very strong background in population biology. One geneticist in this group might also be involved, either directly or collaboratively, in managing breeding populations to conserve major genes.

8.1.4 Cryopreservation

Two scientists with training in physiology of reproduction related to semen and embryo production, collection and preservation are recommended.

For cattle, semen from stocks of interest can undoubtedly be collected at one or more of the many centers engaged in artificial insemination in cattle. In this case, NBAGR would need only to provide storage and data bank services for appropriate amounts of semen as determined by the program's geneticists and Technical Advisory Committee. This may also hold for some of the other species and, possibly, for embryos from certain herds. However, for some species, semen and, especially, embryo collection and preservation may need to be done by NBAGR. Some embryo transfer work will also be needed, to check on viability of embryos stored. Staffing in these areas should be planned only after consideration of alternatives available through collaborating institutions.

8.1.5 Information dissemination

The need for reports on genetic resources available and their status, for use by collaborating institutions and by national and international policymakers and potential users indicates the need for an information specialist. This person might or might not be a part of the data management systems group.

Recommendation: It is recommended that NBAGR should plan initially for a staff consisting of about 15 scientists: 6 trained in quantitative genetics and breeding, 4 in population genetics and genetic characterization and two each in data processing and in physiology of gamete and zygote production and storage. Each scientist position will require one or more technical support positions. In addition, there should be a professional position assigned to preparation and dissemination of information.

8.2 Project Coordinator and Consultants

It is assumed there will be an external Project Coordinator for the program, as is customary with bilateral projects. The Design Team recommends that this person be a highly qualified livestock geneticist and breeder, if possible with prior experience in India or at least familiar with India's animal genetic resources. In addition to the strictly management aspects of a bilateral project, this person would be expected to provide professional advice on design of genetic resource characterization and conservation activities, and on selection of consultants and trainees.

In addition to the Project Coordinator and permanent NBAGR staff, it is envisioned that external consultants would be brought in to assist with development of the program in each of the major program areas, i.e. breed characterization with regard to both performance traits and genetic polymorphisms, data management and cryopreservation. Consultants should be carefully selected, with input from the NBAGR Director and staff, Technical Advisory Committee and the Project Coordinator, to complement existing expertise and to meet specifically defined needs.

Recommendation: It is recommended that provision be made for 12 person-months of expert consultations in addition to the Project Coordinator, for the first year of the program, and 8 person-months for each of the subsequent three years of the program.

The first year might involve 4-month consultancies in the areas of breed characterization, genetic polymorphisms and data management. Alternatively, if the Project Coordinator is an expert in animal breeding, this person might provide the desired input on breed characterization, leaving funds for a longer consultancy in another specialty, or for a consultancy in an additional area. In the second year, experts in the areas of genetic polymorphisms and in cryopreservation are suggested.

8.3 Training

The Design Team has been advised that training should be relatively short term post-doctoral training based on sepecific needs and, with the exception noted below, we concur.

In the absence of specific knowledge of the personnel available it is difficult to state specific needs. However, we foresee opportunities to accelerate achievement of the goals of NBAGR by advanced training in the areas of data management and computer technology, in methods of genetic characterization of breeds, and in quantitative genetics. There may also be a need for additional training in the areas of superovulation, embryo collection and storage; we visited several institutions from which people had been sent or are being sent for training in this area, but did not get a clear picture of the success rates being achieved. (We do note the team's view that adequate investment of staff and resources to create one or two high quality programs in this area in the country would likely produce a greater return than support of a large number of programs with limited expertise and resources).

One area in which we suggest consideration of the possibility of pre-doctoral training is quantitative genetics and animal breeding. In the institutions we visited, we did not identify individuals with advanced training in current methods of genetic evaluation such as use of the animal model to estimate breeding values, nor those indicating extensive experience in design of selection or mating plans using current methodologies available. This may have been because of the brevity of our visits and the limited number of institutions contacted. However, if our impression is correct, that training in these areas of expertise is not currently readily available among institutions likely to participate in the proposed animal genetic resources program, we suggest at least two pre-doctoral traineeships to the U.S. in this area during the first phase of the program. Alternatively, post-doctoral traineeships should be for periods of 1 to 2 years.

Recommendation: It is recommended that the program provide for 3 post-doctoral traineeships per year of 6 months duration on average (range 3 to 9 months) for each of the first two years, and two per year thereafter. It is further recommended that there be either 2 pre-doctoral fellowships of 3.5 years each in the area of quantitative genetics and animal breeding, beginning in the first year, or two long-term post-doctoral traineeships in this area.

8.4 Physical Plant Requirements.

8.4.1 Offices and Laboratories

The Bureau is presently housed in buildings of the NDR Institute in Karnal. While this arrangement has provided the Bureau with a location to organize and initiate its work, it has been recognized that it is a temporary situation and plans are well underway for the relocation of the Bureau at its own site and facilities on land that belonged to NDRI. Actually two buildings have been constructed which will be used for office and laboratory space until the permanent Bureau buildings are constructed.

Space needs will include:

1. Office space for scientific staff (suggested initially as 12 or 13 at headquarters but provision should be made for expansion to at least 20).
2. Office and/or laboratory space for technical support staff.
3. Administrative office space.
4. Computer and data processing center.
5. Laboratory space for the genetic polymorphisms and DNA studies - suggested 5 or 6 laboratories of 600 sq.ft. each.
6. Laboratory space for semen and embryo collection, processing and freezing, if this is to be done at the Bureau. As indicated in the staffing plan, an alternative possibility would be to work out an agreement with NDRI to

have this done in their facilities, since they already have much of the equipment needed and have adjacent animal holding facilities. NBAGR could supply additional equipment needed, which could benefit the NDRI program.

7. Liquid nitrogen storage for semen and embryos. (The need for backup storage capability is discussed below).

Detailed architectural plans were not available.

The building layout shown on the preliminary plans for the NBAGR Center at Karnal would appear to be fully adequate in size to accommodate all of these needs.

Office space and a limited amount of laboratory space will be needed at the Regional Center(s) mentioned under Staffing. Presumably this will be negotiated with the host institution where the Regional Center staff are located.

8.4.2 Cryogenic Storage Needs.

Cryopreserved collections should be routinely stored at two locations. Where semen from active breeding populations is being collected and a sample sent to NBAGR, this plus that kept at the originating center will constitute the necessary backup. NBAGR should have a record of semen stores kept at all collaborating institutions as a part of its germplasm data bank. Where NBAGR has the only collection, this should be divided in two parts and stored in two separate locations, as insurance against loss. Location of the backup storage center could be NDRI, Karnal, NBPGR, or another unit engaged in storage of cryopreserved materials. The team's first choice among these would be NBPGR, because of their involvement in preservation activities and the presence of a liquid nitrogen plant there. Also, NBAGR could reciprocate by providing backup storage for NBPGR materials. However, any one of several options would probably be quite satisfactory.

NBAGR should probably have a liquid nitrogen plant, to improve security of the collections and, in the long run, to reduce costs.

Recommendation: The team recommends that the NBAGR develop adequate office and laboratory facilities initially for 20 scientists, provide space for data processing with space to meet needs for cryogenic storage of semen and embryos with a duplicate cryogenic storage capability at a second location.

7. EXTERNAL FUNDING REQUIREMENTS

External funds will be required for essentially three purposes: 1) for the acquisition of special equipment, vehicles, or machinery not available in India, 2) for the contracting of consultants or foreign specialists services, and 3) for training abroad. A summary of external funding requirements is shown in Table 1.

Table 1. Approximation of External Funding Requirements and Allocation Schedule

Item	Year 1	2	3	4	5	6	7	Total
				$ (000)				
Project Coordinator	150	157	165	–	–	–	–	472
Scientific Consultants	120	84	88	92	96	–	–	480
Equipment	600	400	200	50	50	50	50	1,400
Supplies	100	90	90	90	90	90	90	640
Training:								
Long Term	20	40	40	20	–	–	–	100
Short Term	45	45	32	34	36	38	40	270
TOTAL	1,035	816	615	286	272	178	180	3,362

9.1 Equipment

Additional equipment will be required by the NBAGR to facilitate carrying out its program.

The Design Team reviewed the lists of items suggested in the draft reference document and in the light of its observations regarding program needs and priorities makes the following suggestions:

1. that equipment proposed for the subprojects 5.6; 5.7; and 5.8 be modified to the extent that items not directly required by the project for animal genetic resources research and conservation activity be excluded from the list to be acquired with external funding.
2. items in the list required for subprojects 5.1; 5.2 and 5.3 be given high priority and those items listed for subprojects 5.4 and 5.5 be also included for acquisition with external funds. With regard to items 1 and 2, the Team considers that the input of consultants in the genetic polymorphisms area, with regard to most appropriate technologies currently available, be sought prior to ordering major equipment items for this work.
3. especially important is the transport required for the field survey work. The Team suggests that the Bureau acquire specially made field laboratory trucks equipped with items such as those needed for blood sample collection and storage. (Semen collection will probably best be done through the various regional artificial insemination centers).

Our estimate of the total external cost of these items is $1,400,000.

9.2 Specialist Services

These services fall into two categories:

1) long term
2) short term

The only long term specialist service envisioned is for a

Project Coordinator. The Project Coordinator should be an individual with considerable experience in animal genetic resources management. The role would be to assist the Director of the Bureau in defining various program needs and in the execution of the international dimensions of the project. The project should make provision to cover the cost for at least three person-years of time.

A number of short-term specialist consultants are required especially to assist younger scientists in the implementation of laboratory and field procedures. Areas of specialization and basis of selection are suggested in section 8.2. The recommendation is for a total 44 person-months over the first 5 years of the project.

9.3 Training

An important component of foreign currency requirement is for training. The recommendation is for a total of 78 months of short term (average 6 months) training, and for 48 months of long term training.

Recommendation: It is recommended that external funds be made available to the project to enable the contracting of necessary specialists from abroad, for acquisition of materials and equipment and for special training programs abroad.

10. ISSUES.

Most of the issues reviewed in this section have been discussed in other parts of the report. They are summarized here again because the Team considers the resolution of these issues crucial to the operation of the Bureau.

10.1 Fusion of the NBAGR and NIAG

The impression of the Team is that there appears to be different opinions about the role of the Institute in relation to

the Bureau. In addition to organization and administrative considerations, a major task of the Bureau is to determine the degree of similarity or differences among breeds and types within the species and to differentiate these.

This work could be carried out by the staff, with some modifications, of the institute. The team considers this work highly important for determining priority needs for germplasm conservation as pointed out earlier in this report. It is the view of the Team that the two institutions should be fully merged under a single Director of the NBAGR.

10.2 Collaboration between the NBAGR and other Agencies.

The Team found general agreement among most of the persons interviewed, that the work of the Bureau would require a high degree of interaction with the different Institutes, Universities, State Farms, private organizations and others to carry out its work. Yet these relationships have not been implemented to date. There is a need for clarification, and clear definition of a number of issues relating to inter-institutional cooperation that will assure smoother interaction among them.

The Team has recommended that one of the mechanism that should be implemented is the use of Memoranda of Understanding that state the respective institution's responsibilities.

10.3 Staff Recruitment and Promotion Policy.

Current personnel policies place some constraints on Institute and Bureau Directors in selecting their own staff or making changes they consider necessary. A Director may not actively recruit a staff member from another institution to fill a vacancy, for example. Individuals are assigned to positions by the Agricultural Research Service. The system has much to commend it. However, we are concerned that Directors, who have responsibility for their programs, have little to say about the staff in their organization who are the most critical element to

program success.

The Team encourages the Director, NBAGR to vigorously pursue the recruitment of additional qualified staff to fill existing vacancies.

Recommendation: It is recommended that ICAR explore alternative procedures giving greater latitude to Institute and Bureau Directors in recruitment of their key professional staff.

10.4 Priority Setting

With the large number of species (both domesticated and wild relatives of some) that exist in India, as well as the different status of knowledge regarding size, location and composition of populations, some ordering of priorities for identification characterization, etc. is necessary.

In addition, some decisions must be made regarding optimum technical procedures to be applied within each species for their characterization, evaluation and conservation. The Team generally is in agreement with the established priorities as we understand them and suggest that they be further refined to reflect the capability of the staff and the organization of cooperative projects.

10.5 Duplication of Program Activity.

As a general rule, all research requires some level of duplication. Even certain functions often require that they be carried out in more than one location.

The Team is concerned, however, that some techniques such as embryo transfer work are carried out at almost all animal institutes when such costly procedures cannot be justified at more than one or two well developed locations at most. In fact, the Design Team feels that embryo transfer has limited practical value at this time for genetic improvement programs, and is justified for conservation purposes only in quite special cases.

ANNEX - I

ITINERARY

for

USAID Design Team
for
Animal Genetic Resources

16	Feb	Arrival in Delhi, India
17	Feb	Arrival in Delhi, India Meet with officials in ICAR
18	Feb	National Bureau of Animal Genetic Resources/ National Institute of Animal Genetics, Karnal.
19	Feb	National Dairy Research Institute, Karnal. From Karnal to Bhiwani for visit to Gaushala. From Bhiwani to Hisar. Night halt at Hisar.
20	Feb	Haryana Agricultural University, Hisar; Government Livestock Farm, Hisar; Central Institute for Research Night halt at Hisar.
21	Feb	From Hisar to Sri Jiwan Nagar, Dist. Sirsa for visit to Sri Satguru Hari Singh Animal Breeding & Agricultural Farm. From Sri Jiwan Nagar to Jaipur. Night halt at Jaipur.
22	Feb	From Jaipur to Central Sheep & Wool Research Institute, Avikanagar and back. Night halt at Jaipur.
23	Feb	From Jaipur to Agra Night halt at Agra.
24	Feb	From Agra to Central Institute for Research on Goats, Makhdoom and back. Night halt at Agra.

25	Feb	From Agra to Etawah for visiting Jamnapari Goat Breed Conservation in its habitat. From Etawah to Izatnagar. Night halt at Izatnagar.
26	Feb	Visit to Indian Veterinary Research Institute and Central Avian Research Institute. Night halt at Izatnagar.
27	Feb	From Izatnagar to Meerut to visit Project Directorate on Cattle Breeding and Military Farm. Meerut to Delhi.
28	Feb	Report Preparation Meet with D.D.G./ICAR Meet with Dr. Surjan Singh, USAID/NRM
29	Feb	A.M. - Visit National Bureau of Plant Genetic Resources.
29 Feb to 7 Mar		Report Preparation
8	Mar	Team Departs India

ANNEX - II

LIST OF PLACES OF VISIT AND THE DISCUSSIONS HELD WITH VARIOUS PERSONNEL DURING THE VISIT OF THE USAID DESIGN TEAM.

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17 February

ICAR HEADQUARTERS

1. Dr. V.L. Chopra, Director General, Indian Council of Agricultrual Research and Secretary, Govt. of India, Dept. of Agricultural Research and Education.
2. Dr. J.C. Jain, Deputy Director General (AS).
3. Dr. S.C. Chopra, Principal Scientist (AG&B).
4. Dr. P.B. Kundu, Animal Husbandry Commissioner, Dept. of Animal Husbandry & Dairying, Ministry of Agriculture, Krishi Bhawan, New Delhi.

18 February

NATIONAL BUREAU OF ANIMAL GENETIC RESOURCES/
NATIONAL INSTITUTE OF ANIMAL GENETICS, KARNAL.

1. Dr. D.S. Balain, Director.
2. Dr. R. Sahai, Principal Scientist & Head, Cytogenetics Unit.
3. Dr. S.K. Prasad, Principal Scientist & Head, Immunogenetics Unit.
4. Dr. A.E. Nivsarkar, Principal Scientist & Head Animal Conservation and Management Unit.
5. Dr. B.K. Joshi, Senior Scientist & Head, Animal Physiology/Reproduction Unit.
6. Dr. V. Shanker, Senior Scientist, Molecular Genetics Unit.
7. Dr. B.R. Yadav, Senior Scientist, Cytogenetics Unit.
8. Dr. (Ms) S. Bhatia, Senior Scientist, Cytogenetics Unit.
9. Dr. B. Prakash, Senior Scientist, Cytogenetics Unit.

10. Mr. R.K. Vijh, Scientist, Cytogenetics Unit.

11. Dr. Ashwani Sharma, Scientist, Cytogenetics Unit.

12. Dr. P.K. Vij, Scientist (AG&B), Conservation Unit.

13. Mr. Pushpendra Kumar, Scientist (AG&B), Reproduction Unit.

14. Mr. Ranvir Singh, Scientist (AG&B), Immunogenetics Unit.

15. Mr. M.S. Tantia, Scientist (AG&B), Reproduction Unit.

16. Dr. R.K. Malik, Veterinary Officer.

17. Ms. Suman Lata, Computer Technician.

<u>19 February</u>

NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL.

1. Dr. R.K. Patel, Director

2. Dr. M.L. Madan, Project Director, ETT

3. Dr. M.G. Gurnani, Principal Scientist (AG&B), Progeny Testing.

4. Sh. S.K. Talwar, T-4 (Incharge, Photography Lab)

5. Dr. S. Singh, Head, Dairy Technology Division

6. Dr. R. Balachandran, Principal Scientist, Dairy Technology

7. Sh. A.K. Sharma, Dairy Superintendent

8. Dr. T. Prasad, Head, Dairy Cattle Nutrition Division

9. Dr. D.D. Sharma, Senior Scientist, Animal Feed Technology

10. Dr. G.S. Verma, Incharge, Cattle Yard, LPM

11. Dr. C.R. Balakrishnan, Head, Dairy Cattle Breeding Division

12. Dr. V.N. Tripathi, Principal Scientist (AG&B), LPM

13. Dr. V.S. Raina, Scientist, Semen Processing.

SRI GAUSHALA TRUST, BHIWANI.

20 February

HARYANA AGRICULTURAL UNIVERSITY, HISAR.

1. Dr. A.L. Chaudhry, Vice-Chancellor
2. Dr. P.P. Singh, Joint Director, Veterinary & Animal Sciences
3. Dr. S.S. Khirwar, Senior Scientist, Veterinary & Animal Sciences
4. Dr. R.A. Singh, Dean, College of Animal Sciences
5. Dr. Balbir Singh, Professor & Head, Dept. of Animal Breeding
6. Dr. S.R. Chaudhary, Chief Scientist, Dept. of Animal Breeding
7. Dr. A.S. Kanauzia, Professor of Animal Breeding
8. Dr. B.P. Sen Gupta, Senior Scientist and Head, Dept. of LPM
9. Dr. Jitender Kumar, Professor of Animal Breeding.

GOVT. LIVESTOCK FARM, HISAR.

1. Dr. Sant Kumar, Superintendent
2. Dr. Maha Singh Rana, Veterinary Surgeon, Breeding
3. Dr. D.K. Sharma, Veterinary Surgeon, Haryana Herd
4. Dr. K.S. Lather, Veterinary Surgeon, Haryana Herd
5. Dr. Balwant Singh, Veterinary Surgeon, Sahiwal
6. Dr. H.K. Jain, Veterinary Surgeon, Tharparkar
7. Dr. R.D. Bura, Veterinary Surgeon, Home Farm
8. Dr. S.C. Gauba, Veterinary Surgeon, Fodder
9. Dr. S.K. Goel, Dy. Superintendent
10. Dr. Ram Dhari, Veterinary Surgeon, Tharparkar
11. Dr. Devindra Kumar, Veterinary Surgeon, Haryana Herd

CENTRAL INSTITUTE FOR RESEARCH ON BUFFALOES, HISAR.

1. Dr. P.K. Sethi, Principal Scientist (AG&B)

21 February

SRI SATGURU HARI SINGH ANIMAL BREEDING & AGRICULTURAL FARM, SRI JIWAN NAGAR, DIST. SIRSA.

1. Maharaj Bir Singh and others.

22 February

CENTRAL SHEEP & WOOL RESEARCH INSTITUTE, AVIKANAGAR.

1. Dr. B.C. Patnayak, Director
2. Dr. A.L. Arora, Incharge, Animal Genetics & Breeding Division
3. Dr. S.A. Karim, Head of Division, Nutrition
4. Dr. R.S. Srivastava, Head of Division, Physiology
5. Dr. P.S.K. Bhagwan, Head of Division, Animal Health
6. Sh. N.P. Gupta, Head of Division, T.M. & T.C.
7. Dr. D.B. Kalra, Head of Division, Human Resource Development and Training
8. Dr. S. Parthasarthy, Incharge, Technical Section
9. Dr. S.C. Sharma, Incharge, Extension Section.
10. Sh. P.S. Rawat, Incharge, Statistics, Economics & Marketing Section
11. Dr. S.D.J. Bohra, Project Coordinator, Sheep Breeding
12. Dr. Ravindra Kumar, Incharge, Bio-Chemistry Section
13. Dr. P.S. Lonker, Incharge, Meat Science Section
14. Dr. J.S. Man, Incharge, Grassland & Forage Section
15. Sh. S.K. Chopra, Incharge, Fibre Physics Section
16. Dr. A. Maru, Incharge, Computer Section

24 February

CENTRAL INSTITUTE FOR RESEARCH ON GOATS, MAKHDOOM.

1. Dr. N.K. Bhattacharya, Director
2. Dr. B.U. Khan, Principal Scientist & Head, Genetics Division
3. Dr. Ram Nath Roy, Senior Scientist.

26 February

INDIAN VETERINARY RESEARCH INSTITUTE, IZATNAGAR.

1. Dr. P.N. Bhat, Director
2. Dr. V.K. Taneja, Principal Scientist & Head, Biotechnology Division.
3. Dr. R. Nagarcenkar, Former Deputy Director General (AS), ICAR.

CENTRAL AVIAN RESEARCH INSTITUTE, IZATNAGAR.

1. Dr. D.C. Johari, Head
2. Dr. J.N. Panda, Director
3. Dr. Harpreet Singh, Principal Scientist

27 February

PROJECT DIRECTORATE ON CATTLE, MEERUT.

1. Dr. V.D. Mudgal, Director
2. Dr. C.L. Arora, Principal Scientist (AG&B)
3. Dr. R.N. Singh, Principal Scientist (AG&B)
4. Dr. S.N. Kaushik, Principal Scientist (AG&B)
5. Dr. Kirpal Singh, Principal Scientist & Head, Animal Nutrition
6. Dr. S.C. Aggarwal, Principal Scientist (Statistics)

29 February

NATIONAL BUREAU OF PLANT GENETIC RESOURCES.

1. Dr. R.S. Rana, Director
2. Mr. M. Kazim, Head, Germplasm Exchange Division
3. Mr. P.P. Khanna, Head, Germplasm Conservation Division
4. Dr. M.L. Maheshwari, Principal Scientist, Medicinal & Aromatic Plants
5. Dr. B.R. Verma, Senior Scientist, Entomology
6. Dr. A. Majumdar, Senior Scientist, Plant pathology
7. Dr. Nandini Gokle, Nematologist
8. Dr. B. Lal, Senior Entomologist (X-Ray)
9. Mr. R.L. Sapra, Incharge, Genetic Resources Information Center (Computer facilities)
10. Dr. Bhag Singh, Head, Germplasm Evaluation Division
11. Dr. M.N. Koppar, Head, Germplasm Exploration Division
12. Dr. K.P.S. Chandel, Joint Director, National Facility for Plant Tissue Culture Repository.

ANNEX - III

Terms of Reference

Broadly speaking, the proposed design team should have the following terms of reference :

1. Assessing the kinds and types of genetic resources to be conserved including the rare and endangered breeds/species and their immediate wild ancestors. Other commonly popular Indian breeds and species alongwith projection of their future requirement shall also form a part of this activity.
2. Taking the inventory of existing animal genetic resources and assigning their contribution, present status and problems and strategies for their optimum exploitation.
3. Revising plans for bringing populations to the level equivalent to the holding capacity of the eco-system.
4. Assessment of the existing programmes, manpower available and its requirement, laboratories and their facilities now available and which need to be made available for carrying out all such work under optimal conditions.
5. Assignment of research work needed to be done in respect of methods of conservation/preservation including genetic and physiological aspects of cryopreservation.
6. Necessary infrastructure facilities needed in terms of building and laboratory equipments etc. at different places to be involved in the proposed network set up.
7. Assignment of the supporting and service roles of different Institutes, Universities, Colleges, Departments and Private Organizations to be involved in such work.
8. Assignment of the training and development of necessary manpower as well as educational and training needs required to be set up.

SPECIFIC TASKS AND MAJOR THRUST AREAS AND PRIORITIES TO BE ADDRESSED BY THE DESIGN TEAM

1. Development of necessary infrastructure facilities both at the main campus and at other places throughout the length and breadth of the country in the form of a network programme on genetic resources.
2. Survey and collection of information on various livestock and poultry germplasm resources.
3. Development and establishment of National Information Repository/Data Bank on animal genetic resources including poultry.
4. Development of gene banks both under 'in situ' and 'ex situ' conditions.
5. Comparison and genetic characterization of breeds.
6. Training and development of necessary manpower and establishment of educational and training facilities.
7. Creation of research facilities for exploring genetic diversity within and between breeds as well as for conducting basic and fundamental research in animal genetics with special emphasis on recombinant DNA, RFLPs and gene mapping work, etc.
8. Developing suitable protocols and tie-up programmes for inter institutional collaboration at national, regional and international level.
9. Import and export aspects of animal germplasm resources.

Glossary of Terms.

Composite	-	Population created from crossing among two or more breeds and subsequent inter se mating among the crossbred progeny.
DNA	-	Deoxyribonucleic acid, the genetic material transmitted in the nucleus of the sperm and egg and present in all cells of the mature organism.
DNA fingerprinting	-	molecular technique for very fine scale resolution of differences in DNA; used for identifying genetic differences between individuals.
Genetic distance	-	Measure of genetic difference between two breeds or populations.
Genome	-	The DNA complement of an organism and its organization into chromosomes.
Heterosis	-	Difference (usually superiority) in performance between individuals resulting from crossing different breeds from the average performance of the parent breeds.

Reference Documents.

1. Balain, D.S. Status Paper on Conservation, Evaluation and Management of Indigenous Livestock Genetic Resources of India (for consideration of Indo-US Management Team of Animal Genetic Resources). NBAGR/NIAG, Karnal, India, Jan. 1991.

2. Balain, D.S. Status Report on Biodiversity Conservation of Domestic Animals and Poultry. NBAGR/NIAG, Karnal, India.

3. Balain, D.S. National Animal Gene Bank for India. A Work Plan Manual. NBAGR/NIAG, Karnal, India.

4. National Animal Genetic Resources: National Animal Germplasm Program (US). ESCOP, ARS, CSRS Committee Report, Dec. 31, 1990.

5. K.V. Raman, T. Balaguru and P. Manikandan. National Agricultural Research, Education and Extension Education Systems in India. National Academy of Agricultural Research Management, Rajendranagar, Hyderabad, India, Sept. 1988.