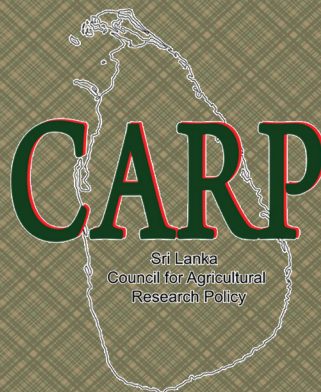




National Research Priorities on Livestock and Poultry 2017-2021

National Committee on Livestock and Poultry



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**National Research Priorities on
Livestock and Poultry**

2017 - 2021

**National Committee on
Livestock and Poultry**

**Ministry of Agriculture
Sri Lanka Council for Agricultural Research Policy
114/9, Wijerama Mawatha
Colombo 07
Sri Lanka
2017**

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Message from the Chairman

Livestock and Poultry Sector assumes a predominant role in the agricultural sector ensuring food and nutrition security of the nation. Similarly, its share in economic development particularly in rural economy is substantial. During the last decade Livestock and Poultry sector has expanded many-fold generating employment at rural level and significantly contributing to food and nutritional security.

Well-coordinated Research and Development (R & D) activities undertaken during the last 5 years by the research institutes under the Ministry of Rural Economic Affairs have generated many valuable outcomes contributing to the rapid development of this sector.

Sri Lanka Council for Agricultural Research Policy (SLCARP) among other mandates has been constantly involved in facilitating the process of R & D prioritization, including the preparation of recently completed research priorities over the last five years. Having re-visited the previous R & D prioritization, SLCARP is pleased to publish the National Research Priorities on Livestock and Poultry 2017 – 2021, prepared with the participation of all relevant stakeholders including the private sector.

The document articulates background, rationale, focus and scope of the research, overall objectives and sub-themes in the following thematic areas: (1) Animal breeding and reproduction (2) Animal Feed, Feeding and Nutrition (3) Animal Health and Hygiene (4) Safety and Quality of Livestock and Poultry (LP) Products (5) Production Systems, Economics and Marketing (6) Livestock Waste, Environment and Society and (7) Animal (Livestock) welfare.

Adherence to the recommendations of this strategic document will certainly improve the quality of the National Agricultural Research Plan (NARP) in the ensuing years, in which situation the Treasury will be convinced that the limited financial resources can be utilized in a more focused and effective manner. This will ensure that the benefits will flow to the general public of this country, which is the ultimate objective of SLCARP.

Dr. S D G Jayawardena
Chairman
Sri Lanka Council for Agricultural Research Policy
01st January 2017

Message from the Secretary/Director

The main function of the Sri Lanka Council for Agricultural Research Policy (SLCARP) is to advise the Government on all matters regarding the organization, co-ordination, planning and execution of agricultural research in Sri Lanka. Research in the agricultural sector comprises research in the plantation, non-plantation, forestry, livestock, poultry, and fisheries sectors.

Livestock and Poultry research activities are mandated with the Department of Animal Production and Health (DAPH). Veterinary Research Institute (VRI) is the research arm of the Department, which is responsible for planning and implementation of research programmes according to the national needs of the livestock and poultry sector. The Faculty of Veterinary Medicine and Animal Science of the University of Peradeniya; Faculty of Livestock, Fisheries and Nutrition of the Wayamba University; Faculties of Agriculture and Science in other Universities and private sector organizations also undertake research on the livestock and poultry sector. Therefore it is necessary for all those institutions, which involve in livestock and poultry research, to join hands to develop long-term research programmes to improve this important sector.

The National Committee on Livestock and Poultry at SLCARP has decided on research projects, concepts, formats and research review formats as tools to monitor and evaluate treasury granted research in order to minimize research duplication and to accelerate the undertaking of priority research projects to derive tangible research outputs.

The Council gratefully acknowledges the unstinted co-operation received from the members of the National Committee and Chairs of the Sub-Committees in the development of the document, and Dr. Oswin Perera, Editor-in-Chief, and the Editorial Board in editing this document. Service rendered by Dr. Frank Niranjana, Secretary of this National Committee, in producing this document is greatly appreciated.

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1. Introduction

The Government of Sri Lanka has given a high priority for the development of livestock and poultry (LP) industries in the country. However, as reflected by key indicators such as lower per capita consumption of animal source food items, lower contribution of LP sector to the GDP, and drain of large amount of foreign exchange to import dairy products, the contribution of LP industries to the national economy is far from satisfactory. Sri Lanka Council for Agricultural Research Policy (SLCARP) clearly identifies the crucial role of research in the development of the LP sector of the country.

The SLCARP appointed a National Committee on Livestock and Poultry (NCLP) with the mandate of prioritizing appropriate research programmes according to the national needs of the LP sector, in order to orient and focus future research activities towards well defined themes or thrust areas. This Committee identified the following seven main themes for development of multidisciplinary research programmes to address the national needs: (a) Animal Breeding and Reproduction, (b) Animal Feeds, Feeding and Nutrition, (c) Animal Health and Hygiene, (d) Safety and Quality of Animal Products, (e) Production Systems, Economics and Marketing, (f) Livestock Waste, Environment and Society, and (g) Animal Welfare. Taking the emerging issues related to the LP sector into account, NCLP identified research priorities under a new theme “Livestock Waste, Environment and Society” as well.

Separate expert consultative meetings were conducted with the participation of leading researchers, academics, industry personnel and other stakeholders for each thematic area, to identify research priorities and to compile a list of topics on which research is deemed necessary. Production, economic, environmental and social implications of the projected increased demand of LP products arising from population and income growth, urbanization and the expansions of the tourism industry were among the key aspects considered in determining research priorities. Subsequently, specified topics were further discussed and the document titled “Research Priorities on Livestock and Poultry for 2017 – 2011” reflects the outcomes of the above stakeholder meetings. The purpose of this document is to provide information to prospective researchers and other stakeholders on the scope, objectives, expected outputs and the research that is needed to achieve the outputs on each theme and sub-theme. It is expected that research programmes on the identified priority areas would promote the contribution of the LP sector to sustainable development of the country.

2. Animal Breeding and Reproduction

2.1. Background and Rationale

Two important considerations for improving the productivity of livestock in Sri Lanka are that (a) the breeds and genotypes of each species are appropriate for the environment and farming system under which they are raised, and (b) that they are managed and fed so as to have the optimum level of reproduction. These considerations are important for ensuring that the farmers who raise livestock obtain the optimum economic benefits in terms of the quantity and quality of the outputs produced, in keeping with the resources and limitations that are characteristic of each farming system. Thus, research on the appropriate procedures and technologies for improved breeding and reproductive management of livestock is of high priority for increasing the productivity of livestock in a cost-effective and sustainable manner.

2.2. Overall Objectives

The overall objectives of the theme are to:

- Make available farm animals which have optimum production performance, are able to survive under the existing environmental conditions, and are economically useful to farmers, utilizing locally available resources; and
- Ensure the conservation and sustainable utilization of farm animal genetic resources (FAnGR).

2.3. Focus and Scope of the Research

The focus of the research programme on Animal Breeding and Reproduction will be on the following three sub-themes:

- Assessing the current status, conserving and improving FAnGR;
- Applying appropriate genetic and reproductive technologies for enhancing productivity; and
- Developing and validating relevant technologies and protocols for farm animal breeding and reproduction.

The scope of the research programme will include the following species based on their national importance.

	Species	Major Outputs
1	Cattle and Buffalo	Milk, meat
2	Goat and Sheep	Meat, milk
3	Pig	Meat
4	Poultry	Meat, eggs
5	Micro livestock	Meat, eggs, other

2.4. Sub-theme I: Assessing the Current Status, Conserving and Improving Farm Animal Genetic Resources (FAnGR)

2.4.1. Scope

This sub-theme will include sustainable utilization of the populations of all FAnGR.

2.4.2. Objectives

- Performance evaluation and selection of suitable animals for breeding programmes
- Establishment of sustainable breeding programmes for commercial as well as conservation purposes.

2.4.3. Expected outputs

- Availability of farm animals with optimum productivity and high adaptability in the applicable environment and farming systems.

2.4.4. Research needed to achieve the expected outputs

- Characterization (both phenotypic and genotypic) of indigenous and cross-bred populations.
- Assessment of breed composition of cross-bred populations.
- Identification of suitable genotypes and determining their performance level (including establishment of field recording schemes, monitoring and evaluation).
- Animal production performance evaluation for selection of breeding animals.
- Development of selection criteria (including potential use of marker assisted selection).
- Planning suitable breeding programs (short-term and long-term) according to the industry and conservation needs.

2.4.5. Expected outcomes

- Availability of suitable genotypes for use by farmers to optimize production and their income.
- Increased in milk, meat and egg production.
- Efficient market operations for FAnGR.

2.5. Sub-theme II: Applying Appropriate Genetic and Reproductive Technologies for Enhancing Productivity

2.5.1. Scope

This sub-theme will focus on applying already available technologies for optimizing productivity of FAnGR.

2.5.2. Objectives

- Enhance the delivery and effectiveness of improved reproductive technologies.
- Assess the applicability of alternative breeding strategies in relevant farming systems.
- Promote the adoption and dissemination of proven technology packages.

2.5.3. Expected outputs

- More effective artificial insemination (AI) services and other reproductive technologies contributing to genetic improvement.
- Adoption of proven packages of technologies by livestock farmers.
- Improved productivity of farm animals.

2.5.4. Research needed to achieve the expected outputs

- Assessing and improving the delivery and success of reproductive technologies.
- Assessing and improving heat detection and reproductive management by farmers.
- Evaluating the breeding soundness and efficiency of breeding animals.
- Developing alternative breeding methods for areas where AI is impractical.
- Testing protocols for cost-effective treatment of reproductive disorders and manipulation of reproductive cycles.

2.5.5. Expected outcomes

- Increased availability of genetically improved livestock.
- More cost-effective livestock production systems.
- Improved reproductive efficiency of livestock.
- Reduced proportion of uneconomical stock.

2.6. Sub-theme III: Developing and Validating Relevant Technologies and Protocols for Farm Animal Breeding and Reproduction

2.6.1. Scope

This sub-theme will focus on molecular-based technologies, reproductive biotechnologies, bioinformatics and genomic selection.

2.6.2. Objectives

- To develop and validate molecular tools and techniques for characterization and evaluation of selected populations of FAnGR.
- To evaluate the genetic merit and multiply superior females through genomic selection and assisted reproductive technologies.
- Conservation of genomes.

2.6.3. *Expected outputs*

- Availability of genetic information for decisions on utilization and conservation.
- Increased accuracy of genetic selection programmes.
- Availability of low-cost embryos from superior females.
- Availability of software tools for recording, analysis and decision making.
- Conservation of threatened breeds or species.

2.6.4. *Research needed to achieve the expected outputs*

- Establishment and application of molecular methods for characterization of populations to determine origin and diversity.
- Search for potential genetic markers that are linked to desirable traits for productivity, product quality and disease resistance.
- Screening for genetic abnormalities in breeding animals (especially AI bulls and cows in nucleus herds).
- Establishment and application of Advanced Reproductive Technologies (ARTs): e.g. multiple ovulation embryo transfer (MOET), in vivo ovum pick-up (OPU), in vitro fertilization (IVF) and in vitro maturation (IVM).
- Cryopreservation of genomes for conservation.
- Adaptation or development of databases and software to be used in the decision making process for utilization and conservation of livestock.

2.6.5. *Expected outcomes*

- Increased national capacity to harness the future potential of gene-based technologies and embryo biotechnologies.
- More cost-effective livestock production systems.
- Improved livelihood of livestock farmers.
- Decreased risks for reduction in biodiversity.

3. Animal Feed, Feeding and Nutrition

3.1. Background and Rationale

The availability of feedstuffs in adequate quantities, and appropriate quality is widely recognized as the main requirement for increasing the production of milk, meat and eggs. This chapter documents the research programs that would be likely to have a significant impact on improving the supply and quality of forages and feedstuffs for farm animals in Sri Lanka. According to the present situation of the industry and predicted changes in consumer demand, research programs on animal feeds, feeding and nutrition should have long term value and contribute towards sustainability of the livestock industry. The priority must still be given for the development of feed resources and that any research carried out with State funds must relate to development programs that can be expected to deliver an improvement in the availability and quality of feedstuffs and forages. Preference should be given to the poultry and dairy sub-sectors, over swine and ruminant meat, when framing research priorities. Other points taken into consideration when prioritizing research areas are listed below:

3.1.1. Poultry sector

- Sri Lanka is self-sufficient in poultry products and the industry is also able to meet the rapidly increasing demand for them. Imported stock of high genetic merit managed under super intensive systems needs quality feeds.
- Though the country produces large quantities of maize, rice by-products and coconut poonac, other feed ingredients such as soybean meal, fish meal, meat & bone meal, micronutrients and feed additives are still imported.
- The quality of the local maize remains below the required standards and needs to be improved.
- Other energy sources available locally are rice bran/rice polish, as well as broken rice and off grade rice. The availability of broken rice is declining and the price is similar to that of maize. Rice that is discarded or off-grade due to poor processing and post-harvest handling, however, is available.
- Small and medium scale farmers attempt in formulating on-farm feed at low level of processing and achieve lesser feeding efficiency due to lack of technical knowledge.
- Local materials that have the potential to be developed as feed ingredients, at least for layer feeds, are available.

3.1.2 Dairy sector

- The primary constraint to increasing the production of milk in Sri Lanka is the lack of quality feeds to exploit the potential of the available dairy animals.
- Despite heavy investment to promote improved forage production, there is very little cultivation of improved forages outside the State farms and as a result, most of the milk is produced on natural forages and the re-growth in paddy fields.
- Some of the issues relating to natural forages are,

- Such forages are characterized by an enormous variation in quality and availability.
- Such forages could be better exploited using dairy buffaloes rather than the improved European breeds of cattle.
- There is no regulation or management of the natural grasslands available and therefore, their utilization is haphazard and unsustainable.
- Forage conservation in the form of silage or hay has not been a practice irrespective to the fact that the forage availability is seasonal.
- Machinery for bailing, chopping or pelleting of dry forage is not available at affordable prices for medium and small scale dairy farmers.
- Forage production for marketing has not been identified.
- The concentrate ingredients available to economically feed dairy animals are limited to coconut poonac, rice bran and a few minor ingredients.
- Lack of feeds, in particular energy is likely to be the biggest obstacle to the plans of the government to increase milk production in Sri Lanka.
- At the same time, a number of materials with a potential to be used as concentrate feedstuffs are available in Sri Lanka.

3.2. Focus and Scope of the Research

The focus of the SLCARP subcommittee on Animal Nutrition is to develop new feed resources and to optimize the utilization of existing feedstuffs. Research is necessary in the following areas:

- Policy initiatives needed to increase availability and quality of feed resources.
- Development and utilization of forage resources, both natural and cultivated.
- Improving the utilization of by-products and maize quality.
- Development of novel feedstuffs from resources available in Sri Lanka and improving nutritive value of low quality or non-conventional ingredients.
- Feeding strategies targeting food safety, environment and welfare.
- Feed conservation and ingredient processing technologies.
- Feed formulation and processing for specific species.
- Technological innovation related to feed processing, ingredient processing and equipment development.

Priority order of the species and their respective products are as follows:

Priority Order	Products
1. Cattle/Buffalo	Milk, meat, skin, manure
2. Poultry	Eggs and meat, manure and by-products
3. Goat/Sheep	Meat and milk, skin and manure
4. Pig	Meat
5. Microlivestock	Eggs, meat, milk

3.3. Overall Goals

The overall goals of the theme are to increase the availability of animal feeds by:

- Increasing the local production of ingredients currently being imported, improving the quality of locally produced ingredients and by developing local substitutes for imports, wherever possible, for the growing poultry sector.
- Improving the utilization of locally available and exotic feed resources to obtain optimum productivity of cattle, buffalo and goats in Sri Lanka.

3.4. Sub-theme I: Policy Initiatives

3.4.1. Scope

This sub-theme suggests studies that will generate the information necessary to develop suitable policies to ensure a sustainable growth in the supply of feed ingredients and concentrated feeds, and focuses on the following areas:

- Inventorize new and exotic feed resources and make projections for the requirements of the energy/protein feed ingredients and additive for the poultry and dairy sectors up to year 2025.
- Identify suitable measures to support small and medium scale feed producers and intermediate processors and suppliers of feed ingredients.
- Study marketing and quality problems associated with small-scale farming of currently imported ingredients and their processing in the field.
- Quality standards for feed and feeding and products.
- Identify the changes in land use and tariffs needed to support the growth of the animal feed sector.

3.4.2. Objectives

- To generate quality information needed for policy making to facilitate the development of the animal feed sector.

3.4.3. Expected outputs

- Sound long term Government policies on animal feed resources management based on comprehensive scientific information.

3.4.4. Research needed to achieve the expected outputs

- Projections of the requirements feed ingredients and feed additives for the livestock and poultry up to year 2025.
- Document and inventorize local and new unexploited feed ingredients and additives.
- Survey small and medium scale feed producers to obtain baseline information and the technical support needed with regard to technology, training, equipment, small-scale processing, and incorporation of local feed ingredients in feed formulae, laboratory analysis and troubleshooting.
- Feed formulation technology and training.
- Marketing and quality problems associated with small-scale feed crop farmers in Sri Lanka including a study of appropriate drying and processing methods.
- Quality and safety of all feed ingredients.

3.5. Sub-theme II: Development and Utilization of Forage Resources

3.5.1. Scope

This sub-theme focuses on improving the exploitation island-wide natural forage resources such as grasslands and tree fodders as well as the development of cultivated forages in a more commercial manner.

3.5.2. Objectives

- Improve the utilization of natural grasslands and other vegetation found in Sri Lanka for cattle and buffalo.
- Improve the utilization of traditional and exotic tree fodder varieties through selection and management.
- Develop commercially viable methods of making fresh and preserved forages such as dry forage and silages particularly baled hay - for high producing dairy cows.

3.5.3. Expected outputs

- Quality forages, both fresh and conserved will be available to farmers to feed their dairy cattle at affordable price.
- Methods will be developed to utilize the natural grasses and fodders abundantly available in Sri Lanka for feeding ruminants.
- Scientific principles will be applied to the management of local and exotic tree fodder varieties to improve their utilization.

3.5.4. Research needed to achieve the expected outputs

- Study the methodology and economics of producing high quality commercial grass/legume forages and their conservation under intensive conditions.
- Survey the markets and promotion needed to ensure adoption feeding of preserved forages by farmers.
- Introduce high productive new varieties and assess digestibility and nutritive value of recently developed varieties of tropical forages.
- Study the production of commercial level planting materials for improved grass and legume varieties.
- Develop a system of classifying forages that can be used commercially; study the use of the indices Relative Feed Value (RFV) and Relative Feed Quality (RFQ) for this purpose.
- Study practical and commercial methods of improving the utilization natural forages.
- Study the natural grasslands in Sri Lanka in relation to location, soil and vegetation and ecological considerations including the utilization for dairying.
- Study the use of scientific management methods to improve the productivity of traditional and exotic tree fodders in Sri Lanka.
- Appropriate machinery for feed processing, conservation and feeding.
- Develop suitable pasture and fodder varieties for different agro-climatic zone.

3.6. Sub-theme III: Development of Concentrate/Feeds Using New Technologies and Under- Utilized Local Materials

3.6.1. Scope

This sub-theme will focus on the development of concentrate ingredients from the wide variety of locally available seeds and other materials that are generated by agro-industry as well as in households, and are abundantly available but not fully exploited.

3.6.2. Objectives

- Generate information on all aspects of using such materials including nutritive value, anti-nutritional factors, processing methods and feeding trials.
- Determine practical and economic methods of making such materials available to feed manufacturers and farmers.

3.6.3. Expected outputs

- Increased availability of substitutes to replace the major feed ingredients presently imported for poultry feeding.
- Increase in the range and variety of feed ingredients available to formulate dairy cattle rations.
- Development of technologies to improve quality and convert available materials into feed ingredients.

3.6.4. Research needed to achieve the expected outputs

- Inventorize the likely materials that can be developed as feedstuffs.
- Study the potential and economics of other energy substitutes to replace maize and develop appropriate processing technologies to improve quality.
- Study the potential and economics of processing by products for inclusion in dairy/poultry rations.
- Develop methods to process local mineral sources such as Eppawala rock phosphate, dolomite and calcite into feed grade mineral supplements for animals.
- Use of feed additives (enzymes, pre/pro biotics) in improving animal productivity and food safety and to reduce environmental pollution.
- Invent protocols to improve palatability and availability of nutrients from underutilized local ingredients.

4. Animal Health and Hygiene

4.1. Background and rationale

Over many decades various infectious and non-infectious causes have been implicated to cause diseases in livestock, poultry and aquatic animals. These diseases cause economic losses to farmers in terms of high mortality, poor growth, production losses, high therapeutic costs or low quality and less marketability of products of animal origin. Strategic and/or tactical control of these diseases has been hindered by many factors including inadequate understanding of epidemiology, lack of information on the strain and generic makeup of the pathogens circulating in the local environment and lack of rapid, highly sensitive and highly specific field and laboratory diagnostic facilities that suit the local needs. Therefore, there is a need to improve diagnostic capabilities and to develop vaccines, cost effective therapeutics and therapeutic regimes to prevent, control and ultimately eradicate these infections successfully.

4.2. Focus and Scope of the Research

The scope of Animal Health research is to protect and enhance the quality and quantity of food of animal origin by preventing and controlling diseases affecting livestock through improved disease detection, treatment and control programmes.

The focus of the research under this theme will be on the following sub-themes:

Sub-Theme I: Establish or develop novel techniques to facilitate rapid and early detection of pathogens.

Sub-Theme II: Strategies to control and prevent infectious and non-infectious diseases of livestock, poultry and aquatic animals.

Sub-Theme III: Establish methods to detect, analyze and respond to zoonotic, emerging and re-emerging diseases.

Sub-Theme IV: Improve the knowledge and understanding on: (a) Genetic variations, virulence, drug resistance of pathogens; and (b) Host's responses in relation to endemic & exotic infectious diseases, in order to implement appropriate intervention strategies.

Sub-Theme V: Epidemiological studies on diseases of livestock, poultry and aquatic animals to understand disease burden, economic impacts, origin, dissemination and phylogenetic relationships.

Sub-Theme VI: Improve veterinary practices to ensure food safety and thereafter, quality assurance that will increase food security and enhance trade and exports.

Sub-Theme VII: Quality control of pharmaceutical and biological products to ensure economical and effective treatment plans.

Sub-Theme VIII: Health issues at animal and human interface.

Sub-Theme IX: Impact of environmental changes on animal health.

4.3. Sub-Theme I: Establish or develop novel techniques to facilitate rapid and early detection of pathogens

4.3.1. Scope:

To develop and validate quick and effective tools and technologies to diagnose diseases of livestock, poultry and aquatic animals, that affect production, trade and public health. This will include the development of rapid, pen-side or field tests to identify pathogens.

4.3.2. Objectives:

- Develop rapid and accurate diagnostic methods for early disease diagnosis.
- Validate the introduced tests.
- Establish cost effective and practical diagnostic techniques to detect animal pathogens.

4.3.3. Expected Outputs:

- Availability of expertise, procedures, tools and techniques for rapid disease diagnosis.
- Availability of cost effective and practical diagnostic methods.
- Improvement of the wellbeing of livestock, poultry and aquatic animals.

4.3.4. Research needed to achieve expected outputs:

- Introduction of rapid immunological, molecular and other techniques for early disease diagnosis in livestock, poultry and aquatic animals.
- Development of cost effective methods suitable for field conditions and transmissible disease prevention.
- Monitoring and evaluating effectiveness of the developed techniques.

4.4. Sub-Theme II: Strategies to control and prevent infectious and non-infectious diseases of livestock, poultry and aquatic animals

4.4.1. Scope:

To introduce effective tools, methods and measures to control and prevent infectious and non-infectious diseases of livestock, poultry and aquatic animals. This will include vaccines, biologicals supplements and treatment of intoxications.

4.4.2. Objectives:

- To develop technology driven vaccines and biologicals.
- To develop protocols based on scientific arguments and adopt specific biosecurity measures to prevent prevailing pathogens.

- Establish accurate analytical tests to identify different causes of non-infectious diseases.
- Technology adapted measures for eliminating multifactorial diseases.

4.4.3. *Expected Outputs:*

- Vaccines and biologicals with improved efficacy and quality.
- Availability of appropriate regimes and biosecurity measures to reduce disease prevalence leading to eradication.
- Availability of analytical tests to identify non- infectious diseases.
- Identifying risk factors of multifactorial diseases.

4.4.4. *Research needed to achieve expected outputs:*

- Develop effective vaccines and biologicals to prevent and control diseases.
- Development and evaluation of technical procedures and biosecurity measures.
- Develop tools and analytical tests for early detection of non-infectious diseases.
- Determine multifactorial disease generating factors.

4.5. Sub-Theme III: Establish methods to detect, analyze and respond to zoonotic, emerging and re-emerging diseases

4.5.1. *Scope:*

Early detection is essential to the control of zoonotic, emerging and re-emerging infectious diseases that affect both animal and human health. Appropriate and efficient responses to such diseases rely on rapid recognition of their presence and diagnosis of their causes. In this context, it is of prime importance to establish novel, rapid, field level diagnostic techniques to detect these diseases and to identify strategic, cost-effective and affordable interventions to control and prevent them.

4.5.2. *Objectives:*

- Develop novel, field diagnostic tools to identify known zoonotic, emerging and re-emerging pathogens as well as to distinguish new pathogenic species, strains, and genotypes.
- Develop rapid, accurate, inexpensive diagnostics methods for the simultaneous identification of multiple pathogens.
- To identify strategic, cost-effective and affordable interventions to control and prevent zoonotic, emerging and re-emerging diseases.
- Develop vaccines and new drugs for disease prevention and control.

4.5.3. *Expected Outputs:*

- Establish high containment facilities (BSL III) to study zoonotic and emerging diseases.

- Information on the basic epidemiology (morbidity, mortality, and economic burden) of zoonoses, emerging and re-emerging diseases.
- Information on the novel, unreported diseases in the country.
- Availability of expertise, procedures, tools and techniques to develop new diagnostic methods in order to control existing zoonotic diseases of livestock, poultry and aquatic animals.
- Better policy plans to prevent and control zoonotic and emerging diseases.

4.5.4. Research needed to achieve expected outputs:

- Molecular characterization of the causative agents of zoonotic, emerging and re-emerging diseases in livestock, poultry and aquatic animals.
- Molecular epidemiology studies of zoonotic, emerging and re-emerging pathogens to understand the origin, distribution pattern and phylogenetic relationship of the organisms.
- Develop rapid diagnostic tools (molecular and immunological/serological assays) to detect the causative agents.
- Establish standardized procedures to evaluate the antibiotic susceptibility of causative agents of zoonotic diseases.
- Devise methods to analyze surveillance data through time.
- Establish surveillance and monitoring system databases.
- Conducting cost-benefit, cost-effectiveness, and affordability for analyses of zoonoses interventions.
- Develop vaccines to control zoonotic and emerging diseases.
- Effectiveness of antiseptics, antibiotic and antiviral agents and herbal products in controlling zoonotic bacterial and viral infections.

4.6. Sub-Theme IV: Improve the knowledge and understanding on (a) Genetic variations, virulence, drug resistance of pathogens; and (b) Host's responses in relation to endemic & exotic infectious diseases, in order to implement appropriate intervention strategies

4.6.1. Scope:

The scope includes the major and emerging infectious and parasitic diseases of production animals (livestock, poultry and aquatic species) that undermine the sustainability of animal production industry. These endemic, exotic or vector borne diseases occur as a result of changes in host, pathogen and environment interactions. Variation in environmental factors, host susceptibility and pathogen virulence (genotype and environmental niche) lead to varying disease outcomes. Thus, better understanding on genetic variations of the pathogens and variation in host disease susceptibility would help to strengthen the disease diagnosis, control and prevention.

4.6.2. Objectives:

- To study the genetic variations of pathogens by genetic tools (sequencing, exploration of gene polymorphisms) to identify their mode of spread, evolution and life history and to determine their antimicrobial/anthelmintic (drug) resistance or resistant genes.

- To explore how both pathogen genotype and environmental niche influence the virulence and transmission of the pathogen.
- To determine how variance in host traits can explain susceptibility to pathogens (differences in innate and acquired immunological response, behavioral and life- history traits).
- To identify of genetic variations in different livestock species to understand the molecular basis of susceptibility and resistance to diseases.

4.6.3. *Expected Outputs:*

- Improved knowledge on pathogens (genomics and proteomics) to identify better therapeutic targets, to develop new techniques to identify organisms and methods of reducing virulence of organisms.
- Information on better vaccine strains or candidates to control infectious diseases affecting production animals.
- Establish testing facilities for detection of pathogens or specific antibodies in serum/blood.
- Information on the risk to animal health by the presence and evolution (gene deletion, acquisition, single nucleotide polymorphisms) of infectious agents.
- Information on tools to control the exposure of domestic animals to pathogens, and novel and economical methods to treat sick animals.
- Knowledge to develop disease resistant breeds.
- Better understanding on the evolution of drug resistance and virulence of pathogens.

4.6.4. *Research needed to achieve expected outputs:*

- Explore the mechanisms by which pathogens mutate or adapt to host species and develop resistance to existing drugs.
- Characterization of emerging infectious agents affecting production animals and determine their interactions with the host and the environment.
- To study phenotype, genotype and virulence of newly discovered pathogens.
- Molecular characterization of pathogens (gene based, multilocus sequence typing, whole genome sequencing etc.).
- Mapping spatial distribution of pathogens.
- Identify genetic determinants of disease resistance of host (both at individual and population scale).
- Study on zoonotic diseases that have significant impact on animal health (e.g. Tuberculosis).
- Developing novel tools for defining disease biomarkers.

4.7. Sub Theme V: Epidemiological studies on diseases of livestock, poultry and aquatic animals to understand disease burden, economic impacts, origin, dissemination and phylogenetic relationships

4.7.1. Scope:

To conduct well planned studies to generate information needed for implementing policies and sustainable and cost effective programmes to prevent, control and eradicate both infectious and non-infectious diseases of livestock, poultry and aquatic animal species.

4.7.2. Objectives:

- Establish comprehensive monitoring, screening and surveillance systems for prevention, control and eradication of infectious and non-infectious animal diseases including endemic, emerging and transboundary diseases.
- Increase availability of baseline data and information on ecology and epidemiology of animal diseases and health issues.
- Develop core competencies in epidemiology and use of epidemiological tools for assessing disease and health status of animals, disease prediction, defining health priorities, decision making and providing policy recommendations for appropriate action.

4.7.3. Expected output:

- Planning and implementation of sustainable and cost effective programmes for prevention, control and eradication of animal diseases and guide evaluation of such programmes.
- Protection and promotion of animal and human health.
- Development of appropriate disease control policies.
- Prioritize allocation of health resources and determine economically optimal level of allocation.
- Improve biosecurity and ensure food safety.

4.7.4. Research needed to achieve the expected outputs:

- Studying, screening, surveillance and monitoring of endemic, epidemic, sporadic, emerging/re-emerging, exotic/transboundary disease situations and health conditions of both infectious and non-infectious origin.
- Studies to identify concepts of disease causation by interplay of disease determinants and identification of populations at risk.
- Develop descriptive analysis of disease distribution and identification of long term trends and patterns of diseases and health associated conditions.
- Quantification of disease/ health conditions via obtaining measures of disease frequency and association.
- Studies to describe a health hazard and clinical course of a disease or health condition.
- Conducting risk assessment studies for systematic characterization and estimation of a probable health hazard.

- Conducting policy evaluations and economic analysis for national and industry based disease control programmes.

4.8. Sub-Theme VI: Improve veterinary practices to ensure food safety and thereafter, quality assurance that will increase food security and enhance trade and exports

4.8.1. Scope:

During treatment and control plans of animal diseases, chemically diverse medicinal and biological products have to be used in productive animals. It is a mandatory responsibility to ensure chemical and microbiological quality of the food that had originated from treated animals, at the point of entry to the food chain. In order to fulfill the consumer safety Good Veterinary Practices (GVP) should be adopted at different phases of animal production.

4.8.2. Objectives:

- Ensure food safety in terms of chemical residues.
- Ensure microbiological food safety.
- Improve the analytical laboratory capabilities in Sri Lanka.
- Implement quality assurance systems.
- Improve domestic and international trade.

4.8.3. Expected Outputs:

Availability of quality assured animal originated food products, free of hazardous chemicals, toxicants and bacteria, thereby enhance international trading opportunities

4.8.4. Research needed to achieve expected outputs:

- Investigation of chemical residues, toxicants in food commodities of animal origin
- Studies on Food Borne Pathogens, contaminants and their antimicrobial susceptibility in a quality certified laboratory setting.

4.9. Sub-Theme VII: Quality control of pharmaceutical and biological products to ensure economical and effective treatment plans

4.9.1. Scope:

In the event of a disease outbreak effective and economical pharmaceutical products for treatment and biological products for disease prevention should be available. The Pioneer Products which are market-leads may be expensive. Hence after expiry of patent protection, Pioneer Products may be substituted with Image Products after ensuring bioequivalence and clinical efficacy.

4.9.2. Objectives:

- Ensure efficacy and target species safety of pharmaceutical & biological products.
- Ensure consumer safety.
- Ensure environmental safety.

4.9.3. Expected Outputs:

- Availability of Veterinary Pharmaceutical & Biological Products effective for treatment and control of animal diseases without a health risk to consumer and environment.

4.9.4. Research needed to achieve expected outputs:

- Conduct well designed clinical trials to compare Image Products against the Pioneer Product which is the market-lead.
- Carryout pharmacokinetic studies to establish Maximum Residue Limits (MRLs) and With-holding Periods (WPs).

4.10. Sub Theme VIII: Health issues at animal and human interface

4.10.1. Scope:

To conduct well planned studies for early detection of zoonotic pathogens/diseases and health hazards associated with human-animal interface and establishment of warning systems for quick and coordinated response for ensuring and improving public health.

4.10.2. Objectives:

- Strengthen the veterinary public health sector through establishment of effective and sustainable monitoring, screening and surveillance systems for prevention, control and eradication of endemic, emerging, transboundary zoonoses and hazards associated with human-animal interactions.
- Minimize risks related to direct and indirect interactions between humans, food animals, companion animals and wild animals including occupational hazards, food borne hazards and drug resistant pathogens.
- Improve disease reporting and risk communication to ensure rapid multidisciplinary action to control disease/ health challenge.

4.10.3. Expected output:

- Planning and implementation of effective and sustainable programmes for prevention, control and eradication of zoonotic animal diseases and health hazards associated with human-animal interactions.
- Protection and promotion of public health.
- Improve biosecurity.
- Strengthen multidisciplinary collaboration.

4.10.4. Research needed to achieve expected outputs:

- Studies to identify, assess and manage risks associated with direct and indirect interaction between human and animals including endemic and emerging zoonoses, occupational hazards, food borne hazards and drug resistant pathogens.
- Understand drivers of zoonotic disease emergence and emergence of drug resistant pathogens in human populations.
- Study the basics of zoonotic disease dynamics; including transmission dynamics, to use appropriate disease control strategies and surveillance programmes.
- Understand reservoirs of diseases with special emphasis on wild animals as reservoirs.
- Optimization of wildlife disease surveillance.
- Studies to identify drug resistance.

4.11. Sub-Theme IX: Impact of environmental changes on animal health

4.11.1. Scope:

Animal production systems, environmental changes including climate changes and animal health, have complex interactions. Human activities such as deforestation and pollution are large scale contributors to global warming and climate change. Accordingly animal health can be affected by the emergence and re-emergence of infections; some are transmitted by vectors depending on weather changes.

4.11.2. Objectives:

- Ensure environmentally friendly practices at all phases.
- Enhance the awareness of disease risks during fly rising seasonal variations.
- To have a preparedness programmes for seasonal outbreaks.

4.11.3. Expected Outputs:

Increase the awareness and preparedness to animal health risks due to deforestation and habitat pollutants.

4.11.4. Research needed to achieve expected outputs:

- Compare and contrast the climatic changes of specific areas.
- Study disease epidemiology against changing weather patterns such as extreme weather events (i.e. storms, flooding, long droughts, heat waves, etc.).
- Identify predisposing factors for recent disease outbreaks.

5. Safety and Quality of Livestock and Poultry Products

5.1. Background and Rationale

The nutrients contained in animal products are essential in the human diet due to the fact that it is vital to consume them in order to achieve normal growth, reproduction, proper health and wellbeing. However, affordability and quality of animal products are not satisfactory in Sri Lanka. Low animal source food consumption has led to a nutritional crisis, particularly among some social segments. In this circumstance, high quality Livestock and Poultry (LP) products need to be made available at affordable prices both for domestic and export markets.

5.2. Focus and Scope of the Research

The focus and scope are on the following four sub-themes:

- Dairy production and processing.
- Meat production and processing.
- Poultry meat and egg production and processing.
- Quality, safety and marketing of LP products.

5.3. Overall Objectives

To investigate the present status of quality, safety, marketing and entrepreneurial aspects of dairy, meat and poultry industries and to provide guidance in order to make safe and high quality LP products available at affordable prices for domestic and export markets.

5.4. Sub-theme I: Dairy Production and Processing

5.4.1. Scope

The sub-theme will focus on manufacturing of cost effective, quality and safer dairy products for consumers with minimum impacts on the environment while maximizing the utilization of locally available resources and also ensuring the quality and safety of imported dairy products.

5.4.2. Objectives

- Ensure the monitoring and quality assurance in dairy products.
- Develop new appropriate technologies in order to manufacture value-added dairy products.
- Investigate the impacts of dairy products on human health and wellbeing.

5.4.3. Expected outputs

- Hazard free dairy products.
- Validated process parameters for small, medium and large scale dairy manufacturing.

- Formulas and process technologies to manufacture new value-added functional dairy products.
- Appropriate technologies to preserve the quality and extend the shelf-life of dairy products.
- Locally formulated starter cultures and probiotics and prebiotics for fermented milk products.

5.4.4. Research needed to achieve the expected output

- Risks analyses in dairy value chain.
- Development of rapid detection systems to ensure the quality and safety of milk and milk products.
- Designing and manufacturing of dairy processing equipment.
- Development of validated process parameters for small, medium and large scale dairy manufacturing.
- Development of buffalo and goat milk based novel dairy products.
- Value addition by incorporation of appropriate edible plant based products.
- Development of functional dairy products with health benefits by incorporating probiotics, prebiotics and other agents.
- Development of appropriate novel technologies to achieve quality and safety of dairy products.
- Investigations regarding public health implications of dairy products.
- Investigations on locally available substitutes for imported food additives needed in the manufacturing of dairy products.
- Isolation and characterization of lactic acid bacteria and formulation of starter cultures.
- Whey utilization to generate whey products.
- Cost effective preservation technologies to extend the shelf-life of liquid milk and other dairy products.

Priority order of research areas

Research Thrust Area	Priority
Risk analysis in Dairy Value Chain	First
Rapid Detection Systems	First
Functional Dairy Products	First
Development and Validation of Novel Technologies	First
Buffalo and Goat Milk Based Novel Dairy Products	First
Value Addition	Second
Appropriate Novel Processing Technologies	Second
Public Health Impacts of the Dairy Products	Second
Development of Starter Cultures for Fermented Milk Products	Third
Use of Locally Available Ingredients as Additives in Dairy Processing	Third
Preservation Technologies	Third
Designing and Manufacturing of Dairy Machinery	Fourth

5.4.5. Expected outcomes

- Ensure quality and safety of milk and milk products.

- Availability of new functional dairy products to deliver health benefits to consumers.
- Availability of dairy products incorporated with plant based material.
- Improvement of shelf-life of dairy products.
- Availability of novel techniques for rapid detection.
- Identification of risks associated with dairy product processing.
- Validated new technologies and machineries.

5.5. Sub-theme II: Meat Production and Processing

5.5.1. Scope

This sub theme will concentrate on manufacturing of different cost effective, quality and safe meat products through properly monitored and regulated meat value chain.

5.5.2. Objectives

- To develop novel value added meat products.
- Ensure the monitoring and quality assurance in meat products.
- Standardize slaughterhouses and meat processing plants.
- To develop appropriate technologies and design equipment for meat industry.

5.5.3. Expected outputs

- Quality and safety ensured meat products.
- New formulas for manufacturing of value-added meat products.
- New processing technologies and machinery for meat processing.
- Standards for slaughterhouses to ensure quality and safe meat.

5.5.4. Research needed to achieve the expected output

- Risks analyses in meat value chain.
- Development of rapid detection systems to ensure the quality and safety of meat and meat products.
- To develop validated process parameters for meat processing.
- Ensuring authenticity of meat and meat products.
- Incorporation of locally available plant based material and ingredients to manufacture value added cost effective, quality and safe meat products.
- Development of appropriate novel technologies for meat processing.
- Development of standards for slaughterhouses to ensure quality and safety of meat and meat products.
- Investigation and improvement of slaughterhouse conditions to improve eating quality of meat.
- Development of functional meat products.
- Development of novel preservation techniques to extend the quality and shelf life of meat and meat products.
- Establishment of database for ante-mortem and post-mortem inspection to ensure hazard free meat and meat products.

Priority order of research areas

Research Thrust Area	Priority
Risk Analysis in Meat Value Chain	First
Public Health Impacts of the Meat and Meat Products	First
Rapid Detection Systems	First
Value Addition and Functional Meat Products	First
Use of Locally Available Ingredients as Additives in Meat Processing	Second
Appropriate Novel Processing Technologies	Second
Develop standards for slaughterhouses	Second
Preservation and Shelf Life	Third
Establishment of database	Third
Eating Quality of Meat	Third

5.5.5. *Expected outcomes*

- Quality and safety ensured meat.
- Availability of new functional meat products to deliver health benefits to consumers.
- Availability of meat products incorporated with plant based material.
- Improvement of shelf-life of meat products.
- Availability of novel techniques for rapid detection.
- Identification of risks associated with meat.
- Availability of new processing technologies and formulas for manufacturing value added meat products.
- Better understanding of slaughterhouse conditions and information on ante-mortem and post-mortem findings.

5.6. Sub-theme III: Poultry Meat Processing

5.6.1. *Scope*

This sub-theme emphasizes on manufacturing of value added, convenient poultry meat products and encourages small-scale poultry meat processors to enter into the industry.

5.6.2. *Objectives*

- Improve the productivity of poultry meat processors through developing new value added poultry meat products.
- Encourage small scale poultry meat processing by developing appropriate technology and machinery.

5.6.3. *Expected outputs*

- Formulas and nutritional information on further processed poultry meat products.
- Process technologies for waste handling and conversion of by products to value added products.

- Designs of equipment and technology for small and medium scale poultry processors.

5.6.4. Research needed to achieve the expected output

- Value addition through portioning, minimal processing (marinating, smoking, braising, B.B.Q, etc.) and preparing ready-to-eat products.
- Conversion of poultry slaughterhouse by-products to produce animal feeds and upgrade into edible products.
- Designing of cost effective machinery and technology for small and medium scale poultry meat processing plants.
- Cost effective packaging for preserving poultry meat to ensure longer shelf life.

Priority order of research areas

Research Thrust Area	Priority
Value addition	First
Packaging	Second
Pre slaughter handling of live birds and carcass quality	Second
Equipment and technology	Third

5.6.5. Expected outcomes

- Increased profit margin of the poultry meat processors.
- High quality poultry products.
- Convenient products to the consumers through value addition.
- Additional income and reduced environmental impacts by appropriate waste handling.
- Appropriate technologies and machinery for small scale poultry processing plant to ensure quality and safety of poultry meat.

5.7. Sub-theme IV: Economics and Marketing of Livestock and Poultry products

5.7.1. Scope

This sub-theme emphasizes on optimizing the cost of production and marketing of Livestock & Poultry products.

5.7.2. Objectives

- To determine the current cost of production of LP products under different production systems.
- To gain information and make strategies to mitigate the inefficiencies, wastages, losses in order to improve the productivity of the industry.
- To provide assistance to improve the productivity through an Animal Product Market Information Centre.
- To explore and establish new export trade opportunities for Sri Lankan products.

- To determine the rationality and the relevance of the facts contained in advertising and take remedial measures.

5.7.3 *Expected outputs*

- Establish reliable market information through market surveys.
- Freely accessible databases on actual cost of production of milk, milk products, meat and meat products under different production systems to all the stakeholders.
- Technical advice on efficient use of cold-chain facilities and to improve the existing facilities.
- Opportunities for local producers of quality LP products for export.
- Information on effectiveness of advertising on consumer decision making in purchasing different categories of LP products.

5.7.4 *Research needed to achieve the expected output*

- Market surveys on all the animal products including consumer preference.
- Continuous investigations on determining the actual cost of production of milk, milk products, meat and meat products under different production systems.
- Studies on the existing cold chain facilities available in meat and dairy industries and cost efficient necessary improvements.
- Studies on the potentials for new avenues for export of LP products.
- Studies on the effectiveness of print and electronic advertising of LP products on decision making of consumers regarding consumption of animal products.

Priority order of research areas

Research Thrust Area	Priority
Retailing and Market Information of LP products	First
Cost of Production and Productivity	Second
Identification of consumer preference	Second
Cold-Chain Management and Transportation of LP Products	Third
Potential of Export Market	Third
Impact of Product Advertising on Consumers	Fourth

5.7.5 *Expected outcomes*

- Access to reliable market related information and consumer preference.
- Access to databases on actual cost of production of milk, milk products, meat and meat products under different production systems to all stakeholders through a centralized digitally accessible system including providing advisory services to optimize the productivity.
- Assistance to all stakeholders on establishment and improvement of economically efficient cold chain facilities.
- Export market related new avenues for LP products.
- Better awareness on scientifically unproven facts and myths used by advertising companies regarding the animal products.

5.8. Sub-theme V: Quality and Safety of Livestock and Poultry Products

5.8.1. Scope

This sub-theme concentrates on evaluating the existing levels of safety, microbiological quality and prevalence of harmful food/feeds additives in animal products and making recommendations on improved quality assurance to mitigate the risk to consumers.

5.8.2. Objectives

- To evaluate and develop new strategies and procedures to manufacture quality and safety of LP products.
- Increase the capacity of analytical laboratories for quality assurance of LP products.
- To address the misconceptions and taboos related to LP products.

5.8.3. Expected outputs

- Availability of guidelines and methodologies to evaluate microbial load of LP products.
- Establish safety levels of additives and agents on LP products.
- Procedures to prevent occurrence of food borne diseases.
- Education programs for the public regarding allergies, misconceptions and beneficial attributes of LP products.

5.8.4. Research needed to achieve the expected output

- Evaluation of microbiological quality of raw milk, meat, poultry meat, egg and other products.
- Investigations on food borne microbes that contribute to the different types of spoilage and defects on finished products.
- New approaches to reduce microbial load in raw materials and fresh products.
- Field trails on pharmaceuticals and biologicals used in agriculture and veterinary practices.
- Methods to reduce the existing levels of antibiotics, hormones and chemical residues in LP products.
- Investigations on the prevalence of food borne diseases caused by pathogens and approaches to prevent their occurrences.
- Prevalence of food allergies due to LP products.
- Investigating the beliefs and misconception about milk, meat and egg based products.
- Studies on effect of consumption of LP products on human nutrition and health.
- Development of methodologies for screening Genetically Modified LP products.

Priority order of research areas

Research Thrust Area	Priority
Microbiological Quality of Animal Products	First
Quality Control and Quality Assurance	First
Antibiotics, Hormones (growth promoters) and Chemical Residues in Animal Products	Second
Food-Borne Diseases	Second
Evaluation of Presence of Adulterants	Second
Food Allergies	Second
Nutritional Quality and Health Attributes of Animal Products	Third
Screening of Genetically Modified Animal Foods	Fourth

5.8.5. *Expected outcomes*

- Animal products with higher quality, safety and longer shelf-life.
- Effective and safe use of pharmaceuticals and biologicals in livestock production.
- Increased national and international trade.

5.9. Sub-theme VI: Egg Quality

5.9.1. *Scope*

This sub-theme emphasizes on development of a grading system for eggs and improving the quality of eggs and packaging materials.

5.9.2. *Objectives*

- To improve the productivity of farmers and processors through developing a grading system for eggs and value added egg products.
- Encourage farmers to produce quality eggs and to use appropriate packaging technology.
- To encourage value added and processed egg products.

5.9.3. *Expected outputs*

- Formulas and nutritive values of processed egg products.
- Standards for different egg grades.
- Methods of improving quality of eggs.
- Information on suitable packaging materials.

5.9.4. *Research needed to achieve the expected output*

- Development of appropriate grading systems which encourage farmers to produce eggs that can be marketed easily.
- Value addition through nutritional enrichment, drying, pickling.
- Cost effective packaging for eggs and egg products to ensure longer shelf life.

- Studies on further processing of eggs to cater to diverse market segments.

Priority order of research areas

Research Thrust Area	Priority
Development of a grading system	First
Value addition	Second
Egg Quality	Second
Packaging	Third

5.9.5. Expected outcomes

- Increased profit margin for the egg producers and processors.
- Generation of additional income for egg producers and processors.
- Provide information on suitable packaging materials which extend the shelf life and quality of eggs and egg products.

5.10. Sub-theme VII: By-product Utilization and Waste Management

5.10.1. Scope

The sub theme will focus on producing edible products and LP feed by using slaughter house by-products with minimum impact on the environment.

5.10.2. Objective

- To develop new technologies in order to minimize the environmental pollution.
- To develop new value added products for human consumption.
- To utilize by-products for feeding of livestock and poultry.

5.10.3. Expected output

- New designs of locally adopted effluent treatment plants and systems.
- Formulas and process technologies to produce new products for feeding of livestock.

5.10.4. Research needed to achieve the expected output

- Optimum effluent treatment technologies to minimize environmental pollution.
- Utilization of slaughter house by-products.
- Development of low cost high valued LP feed.

Priority order of research areas

Research Thrust Area	Priority
Effluent Treatment	First
By-product Utilization for Human Consumption	Second

Rendering	Second
Utilization of Skin, Feathers, Bones and other By-Products	Second
Influence on Environment	Second

5.10.5. Expected outcome

- Prevention and control of environmental pollution.
- Reducing the waste of valuable slaughter house by-products.
- Extra income from slaughter house by-products.

6. Production Systems, Economics and Marketing

6.1. Background and Rationale

Food security and poverty alleviation are major concerns of the Government of Sri Lanka. There is a growing demand for livestock and poultry products compared to local production. The country faces the challenge of increasing the production. Intensive livestock production systems depend primarily on specialized genetic stocks in controlled environments while extensive family farming systems use indigenous farm genetic resources which contribute to the poverty alleviation and nutritional status of rural population. Their well-being and nutrition are important to prevent physical debility as they play a major role in the growth of the agriculture sector. In addition, improvement of the existing production systems to cater the rising demand for livestock products and to alleviate the poverty in farming community is also important.

Production/farming systems in Sri Lanka are far from uniform. Considerable variations exist among the system; 1) from mono-crop (single breed) to poly-crop (mixed breeds), 2) from household farming systems, crop based, pastoral and transhumance, 3) expansion agriculture, low external input agriculture, high external input agriculture and new conservation agricultural system, 4) landless, small-medium-large land holdings, 5) irrigated arable land, un-irrigated arable land, parched drylands, grazing lands and forests, and 6) animal type – indigenous, or exotic and crossbred.

Mixed farming systems, in which crops, livestock and fish are integrated on the same farm, are the backbone of smallholder production in developing countries. Although non-ruminants are found in mixed farming systems, they are usually less important than ruminants, and smallholder production is associated with low input - low output scavenger operations. Crop-ruminant systems produce 92% of the world milk supply, all of the buffalo meat and approximately 70% of small ruminant meat. Crop-ruminant systems are probably the most benign from the environmental perspective because they are, at least partially, closed systems. The waste products (crop residues) of one enterprise (crop production) can be used by another enterprise (animal production), which returns its own waste (manure) back to the first enterprise. Crop-livestock-fish integrated systems are widespread in all agro-ecological zones in developing countries, from the lowlands to the highlands and occur under different climatic and soil conditions.

In many ways, Farming Systems Analysis (FSA) implies a departure from standard research procedures. Most national research agencies are organized on a disciplinary or commodity basis, and most of their work is carried out under well controlled experimental conditions. In contrast, FSA as an effective way to translate farmer problems into research requires the collaboration of interdisciplinary teams, extensive field work and experiments outside the research station. Whatever structure is established, two aspects are paramount; long-term sustainability and linkages with research on the one hand and extension on the other hand.

6.2. Focus and Scope of the Research

The focus of Production Systems research will be on the following four sub-themes:

- a) Characterization of Agricultural Production Systems;
- b) Management and improvement of Agricultural Production Systems and Conservation of indigenous species;
- c) Economics, marketing of dairy products and Livelihood Development of dairy farmers;
- d) Policy and Legal Framework (access to grazing rights, water, agro forestry, patent rights, pollution, etc.).

6.3. Overall Objectives

The overall objectives of the outcome of research to be conducted under the above theme are to:

- Develop tools and models to predict changes and sustainability of crop-livestock-fish integrated systems.
- Increased contribution to the national agricultural growth through reduced or minimized impediments to the low-input agricultural systems.
- Fill information gaps and take advantage of policy development.

6.4. Sub-Theme I: Characterization of Agricultural Production Systems

6.4.1. Scope

This sub-theme will focus on creation of a data base to store primary data collected from household and farm surveys, digitizing of surveyed households and farms, and service/inputs providing agencies, and building up to models

6.4.2. Objectives

- To characterize the types of production systems prevailing in the various agro-ecological zones.
- To compile existing research data and create a data base to extract information on production systems.
- To create an inventory of the different service and input providers.

6.4.3. Expected outputs

- Database on various agricultural production systems.
- Conceptual frameworks to analyze mixed systems (crop-livestock; livestock-livestock, crop-fish; livestock-fish, etc.).

6.4.4. Research needed to achieve the expected output

- Desk research on previous studies carried out on characterization of agricultural production systems.
- Identify and prioritize research needed to fill the gap.
- Assessments of sustainability of farming systems; financial feasibility, economic viability, social acceptability and environmental friendliness.
- SWOT analysis of the various agricultural production systems.

- Socio-economic, religious and cultural barriers in integrating livestock components in agricultural production systems.
- Role of integration of livestock in agricultural production systems in improving productivity, profitability and sustainability of marginal production systems.
- Identify strategies to promote participation of youth to agriculture production systems.
- Studies related to the effects of urbanization and rural migration on sustainability of agricultural production system.

6.4.5. *Expected outcomes*

- Better understanding (including constraints and opportunities) of agriculture based production systems (mixed systems) and farming communities in the different agro-ecological zones of Sri Lanka.

6.5. Sub-Theme II: Management and Improvement of agricultural production systems and conservation of indigenous species

6.5.1. *Scope*

This theme will focus on using and developing agricultural production systems suitable to the national economy. Also, the theme will focus on the understanding, using and developing of aquaculture and fisheries practices through community participation, conservation and use of indigenous resources for the long term sustainability of integrated agricultural production systems for alleviation of poverty.

6.5.2. *Objectives*

- To enhance the contribution of the agricultural systems to the National GDP, food security and livelihoods of the people.
- Farming systems integrated with other agriculture systems to generate more income.
- To assess competitive advantages of different agricultural production systems.
- To maintain sustainable ecosystems.

6.5.3. *Research needed to achieve the expected output*

- Feasibility of organic farming of livestock and poultry.
- Environmentally sound farming practices for Low-input farming systems and High-input farming systems.
- Studies related to:
 - Gender aspects related to livestock and fish systems.
 - Examining the existing state of knowledge concerning the contribution of indigenous plants and animals.
 - Examine the evidence of losses of indigenous farm animal genetic resources (FAnGR).

6.5.4. *Expected outputs*

- Improvement of living standards of farming families.
- Enhance the contribution to national agriculture production.

6.6. Sub-Theme III: Economics, Marketing and Livelihood Development

6.6.1. *Scope*

Focus on strengthening vertical and horizontal integration of agricultural production systems, expanding access to markets and increasing efficiency and networking of Farmer Manage Societies (FMS).

6.6.2. *Objectives*

- To improve economic viability of existing agricultural production systems.
- To propose measures to increase resource use efficiency of the system through value-addition, nutrient recycling, waste management and integration.
- To increase technical and entrepreneurial skills of the farmer that are needed to increase the economic efficiency of the farm.
- To educate community on nutritional benefits of livestock products.
- To establish and promote farmer based community organizations to enhance the sustainability of the industry.
- To promote youth participation in agricultural production systems.

6.6.3. *Research needed to achieve the expected output*

- Identification of constraints to the development of markets through value chain analysis.
- Economic and financial analysis of different agricultural production systems.
- Identification of the level of technical and entrepreneurial skills of farmers, their training needs and appropriate methods of skill development.
- Identification of the level of knowledge of consumers on nutritional benefits of crop and livestock products.
- Identification of key success factors for the successful operation of farmer based community systems through case studies.

6.6.4. *Expected outcome*

- Better livelihood for farmers through higher profits.

6.7. Sub Theme IV: Policy and Legal Aspects

6.7.1. *Scope*

This theme will focus on the farmers, herders and pastoralists as custodians of plants and livestock and their role in conserving biodiversity and sustainable livelihoods. A legal framework would create a level playing field between low-input farming systems that conserve genetic diversity, and intensive and industrial systems.

6.7.2. Objectives

- Study the existing threats to the basis of these livelihoods.
- Prevention of legal vacuum when addressing the rights of small farming communities with livestock.
- Exchange, use and conserve indigenous farm animal genetic resource.
- Harmonize veterinary regulations with indigenous animal genetic resources conservation and sustainable use.

6.7.3. Expected outputs

- A legal framework, which is not available now, to address the sustainable continuation of low-input farming systems.

6.7.4. Research needed to achieve the expected output

- Assessment of the impacts of agricultural and related policies on sociological, ecological, and economical aspects.
- Critical evaluation of the current legal system that is biased against non-input systems.
- Objective case studies and study of court cases.
- Studies related to livestock waste management and environmental conservation.
- Minimize the impact of livestock farming on environment (global warming, soil degradation etc.).
- Awareness and dissemination of findings.
- A resource survey of grasslands and the development of suitable policies to exploit them in a sustainable manner.
- Studies on present land-use policies in relation to the development of animal feed resources, particularly forages.

6.7.5. Expected outcomes

- Rights of livestock keepers, farmers, herders and pastoralists as an important step towards sustainable conservation of indigenous breeds as well as the existing farming system are defined.
- Rights of livestock keepers and enhancing their ability to increase productivity through sustainable conservation of indigenous farm animal genetic resources are defended.
- Overcoming seasonal feed scarcity for ruminants in areas with fluctuating seasonal feed availability using crop/livestock integrated systems.
- Integrated nutrient management across soil/water/crop/livestock/fish interfaces or studies on links between those system components.
- Effect of climate change on livestock production systems.

7. Livestock Waste, Environment and Society

7.1. Background and Rationale

Livestock waste, environment and society have many interactive relationships. There are many waste and environmental degradation related and social issues in each of the Livestock and Poultry (LP) production systems and processing units. It is imperative to quantify these impacts and bring about solutions to reduce and minimize damage to the environment while protecting the health of the workers and populations living in the vicinity of LP farms and processing facilities. In this regards, there are weaknesses, inadequacies and lacking of resources in institutional structure and infrastructure.

7.2. Focus and Scope of the Research

Focus and the scope of the research programs are expected to fall within the following sub-themes.

- a) Establishment of databases on wastes, impacts of production systems and improvement of policy.
- b) Comprehensive Livestock Development and Management Plan (CLD&MP).
- c) Waste as a resource.
- d) Application of 3R (Reduce, Reuse, Recycle), Cleaner Production (CP) and Green Productivity (GP) concepts.
- e) Standards and Regulations.
- f) Integrated Organic Farming.
- g) Environmental monitoring, risk assessment and disaster management.

7.3. Overall Objectives

- Establish databases on LP wastes along with present impacts of LP production systems on environment and society.
- Formulate and assist implementation of CLD&MP and comprehensive livestock waste management plan (CLWMP).
- Convert LP waste into animal feed, fertilizer and energy.
- Reduce waste related social and environmental impacts arising from LP production and processing.
- Improve the existing LP production and processing industries with the application of 3R, CP and GP.
- Improve existing standards and regulations for managing LP production and processing wastes.
- Investigate best approaches to establish integrated semi intensive organic farming systems.
- Establish effective environmental monitoring program to reduce risks originating from LP.

7.4. Sub-Theme I: Quantify Waste Generations, Impact on Environment and Society and Formulate New Policy (LP Waste, Environment and Society)

7.4.1. Scope

This theme focuses on formulating or amending the existing policy on waste generations and the impacts of LP waste on environment and society.

7.4.2. Objectives

- To quantify spatially waste generations, storage and disposal from livestock farming systems and processing industries.
- To characterize the wastes to be utilized as livestock feed, fertilizer and in power generation.
- To assess the “willingness to pay” by farmers and entrepreneurs for improved waste and environmental management.
- To formulate or amend the existing policy on waste generations, storage, disposal and impact of LP waste on environment and society.

7.4.3. Expected outputs

- An active database with defined reporting mechanisms that can be updated annually of waste generation, storage methods, transportation and disposals.
- Farm and product level life cycle assessment (LCA) on environmental indicators.
- Report on the present financial status of LP farms and an economic evaluation of “willingness to pay” for improved waste and environmental management.
- Documentation of environmental and social impacts arising from LP productions and processing industries.
- Revised national LP development policy and strategies.

7.4.4. Research needed to achieve the expected outputs

- Situation analysis on waste generation, disposal and utilization in LP farms and processing industry.
- LCA assessments on livestock, products to determine ecological indicators including carbon footprint.
- Economic studies to assess the financial status of the existing farms and “willingness to pay” for waste and environmental management.
- In depth research on public nuisance arising from LP and processing industries.

7.5. Sub-Theme II: Formulation of Comprehensive Livestock Development & Management Plan (CLD&MP) and Comprehensive Animal Waste Management Plan (CAWMP)

7.5.1. Scope

This theme focuses on interdisciplinary research that is needed to formulate CLD&MP and CLWMP.

7.5.2. Objectives

- To formulate and implement CLD&MP
- To formulate and implement CLWMP, complimentary to CLD&MP

7.5.3. Expected Outcome

- Better waste management, disposal and utilization practices in farms and processing industries

7.5.4. Expected Outputs

- Sectoral CLD&MP and CLWMP plans.
- Environmental Management Plan.
- Resource Allocation Plan.
- Monitoring, Risk Assessment and Disaster Management Plans.
- Regulatory and Law Enforcement Plan.

7.5.4. Research needed to achieve the expected outputs

- Consultative research to formulate the CLD&MP.

7.6. Sub-Theme III: Waste as a Resource

7.6.1. Scope

The development of strategies to convert LP waste into animal feeds, biogas and other usable products.

7.6.2. Objectives

- To determine the performance of existing anaerobic reactor and make comparison with a modified Up-flow Anaerobic Sludge Blanket (UASB) reactor.
- To convert different wastes originating from LP and processing industry to economically important products such as animal feeds, organic fertilizer and biogas.

7.6.3. Expected outputs

- Scientifically proven and a justifiable system to convert LP wastes to biogas and liquid fertilizer.
- Developed machinery and equipment for feeding and collection of LP and processing industry waste.
- An organic fertilizer which is superior to inorganic fertilizer.

7.6.4. Research needed to achieve the expected outputs

- Development of cost effective machinery and equipment for collection and processing of input feeds as well as collection of wastes from LP and processing industry for fertilizer production system.
- Studies on LP waste processing systems for the production of organic fertilizer.

7.7. Sub-Theme IV: Application of 3R (Reduce, Reuse, Recycle), Cleaner Production (CP) and Green Productivity (GP) Concepts

7.7.1. Scope

- The application of 3R concept.
- Adoption of odor management systems of biofilters, scrubbers, etc.

7.7.2. Objective

- To apply 3R, CP and GP concepts and techniques to reduce wastes and improve the indoor and outdoor air quality standards in LP production and processing facilities.

7.7.3. Expected outputs

- Improvements in the indoor air quality of LP housing facilities.
- Improvement of the air quality standard around the LP production and processing facilities.

7.7.4. Research needed to achieve the expected outputs

- Simulation studies and air flow modeling of LP housing facilities.
- Studies on odor detection techniques, selection of filter media, air through flow rate and emission height.
- Design foul gas cleaning system under tropical conditions.

7.8. Sub-Theme V: Standards and Regulations

7.8.1. Scope

- Environmental, social and financial impacts of waste originating from the production and processing of LP.
- Health aspects of the workers and neighboring communities.

7.8.2. Objectives

- To define acceptable limits of environmental and social impacts based on minimum radii of influences within LP housing facilities.

- To develop guidelines for conducting studies on social and environmental impact assessment of different livestock farms and farming systems based on previous studies.

7.8.3. *Expected outputs*

- Environmental and social standards of rearing LP and to produce quality products.
- Regulations to protect the LP, human habitats, society and ecosystems.
- Guidelines for conducting studies on social and environmental impact assessment of different LP farms and farming systems.

7.8.4. *Research needed to achieve the expected outputs*

- Evaluation studies on each of the aspects and issues to determine the acceptable limits of social and environmental impacts so as to define the CEA standards.
- Research studies to transform standards to social, economic and environmental benefits,
- In depth research studies to define acceptable risks that can be allowed in the EIA and social impact assessment (SIA) study reports.

7.9. Sub-Theme VI: Integrated Organic Farming (IOF)

7.9.1. *Scope*

- Development of IOF incorporating crop, livestock and aquatic components.
- Potentials for the improvement in quality of LP products.

7.9.2. *Objective*

- To develop integrated organic farming models suitable for different agro-climatic regions.

7.9.3. *Expected outputs*

- Sustainability of integrated organic farming models.

7.9.4. *Research needed to achieve the expected outputs*

- Prefeasibility studies for developing IOF models in different agro-climatic regions, considering material cycles, and social and economic aspects.
- Studies on mass and energy balances.
- Lifecycle assessment on farm products.
- Studies on the kinetics and statistical approaches for the adoption of the concepts, principles, inventions and innovations in different agro ecological regions of the country.

7.10. Sub-Theme VII: Environmental Monitoring, Risk Assessment and Disaster Management

7.10.1. Scope

Environmental monitoring is the key to improving environmental quality and to mitigate the possible risks and impacts. Both physical and biological indicators with regard to disasters are to be monitored and assessed.

7.10.2. Objectives

- To conduct a comprehensive study on the required environmental monitoring methods, standards and systems in different LP farming systems.
- To conduct risk assessment studies on model farms in terms of social, technical, financial and environmental aspects and parameters.
- To develop and provide guidelines for preventing disasters and disaster management, particularly of severe droughts and inundations.

7.10.3. Expected outputs

- Information on instrumentation and other data acquisition methods, including biological indicators, social aspects
- The CEA will be aided to command, control and regulate the environment to improve and maintain healthy conditions for human, animal and ecosystems.

7.10.4. Expected Outcome

- Guidelines for farmers, entrepreneurs, financial institutions, experts, consultants and government agencies on natural, arson, theft and accidental disasters.

7.10.5. Research needed to achieve the expected outputs

- An assessment of instrumentation and data acquisition to measure environmental parameters.
- Studies on the social, financial and environmental impacts of risks of LP farming.
- Comprehensive studies on integrated water resource management in relation to LP farming.
- Development of monitoring, risk assessment and disaster management guidelines for LP farms.

8. Animal (Livestock) Welfare

8.1. Background and Rationale

Concern over welfare of animals is not new and has often been given considerable emphasis, for example by Mahatma Gandhi: “The greatness of a nation and its moral progress can be judged by the way its animals are treated”. However, it is clear that such concern, particularly for animals in our care, has recently increased and continues to increase in many nations.

In a broader sense, the term ‘animal welfare’ includes welfare of a wider range of animals, including companion (pet), laboratory (research), wild, farm (livestock) animals etc., and welfare of different categories of these animals depends on specific needs and could also be discussed in terms of the purposes of keeping them. Globally, with regard to livestock, welfare of animals is recognized as a core component of a responsible livestock sector. It is accepted to be integral to programs that improve animal health, increase livestock production, and respond to natural disasters where animals are involved.

In recent years welfare of livestock has become the focus of an emerging field of scientific research. Much of the basic work has been done in the economically developed countries, and is primarily focused on the problems of intensive animal production systems. However, the methods of animal welfare science are broadly applicable to a wide range of animal welfare problems seen across the spectrum of production methods, and to the global issues of animal welfare during slaughter and transportation.

There are at least three main parties to whom welfare is important. First and foremost, it is important to the animals themselves and then to producers and to consumers. As far as the animals are concerned, we could argue that good welfare is not just of some interest but that it is the only thing that matters to them. To producers, the good welfare is important because it matters to the animal; i.e. there is a positive correlation between good welfare and productivity and also in areas where consumers demand high welfare standards, it can lead to benefits in terms of profitability. Finally, good animal welfare is important to consumers because many cultural/religious traditions encourage efforts to care for animals and there is a growing consensus about the importance of good welfare based on a greater understanding of animals and of our ethical responsibilities for them.

8.2. Focus and Scope of the Research

In Sri Lanka, welfare of livestock has not received much attention in the past. Therefore, the committee is of the opinion that current practices in the management, transportation and socio economic factors that affect welfare of livestock should be examined in detail through the conduct of well-designed baseline surveys and studies. The results should be compared with accepted international norms, and the best practices that are applicable for the conditions prevailing in Sri Lanka should be recommended for adoption.

8.3. Overall Objectives

- To objectively study the optimum conditions for livestock during transportation under Sri Lankan conditions.

- To objectively study the effects of environment and housing on welfare of livestock.
- To study the socio economic factors affecting welfare of animals in Sri Lanka.

8.4. Sub-theme I – Welfare aspects of Livestock and Poultry Transportation (Cattle, Buffalo, Pigs, Goats, Sheep and Poultry)

Transportation is an essential component in livestock marketing and processing. It generates a substantial burden of stress resulting in both animal welfare and economic challenges for the livestock industry. For example in case of pigs, a number of studies have been conducted to evaluate the effects of transport conditions on the welfare and economic losses. Factors of known significance include loading density, journey times, durations and conditions, handling treatment, trailer design, loading method and temperature, both ambient and internal. Knowledge of different space requirements, transport durations, models of transport vehicles, etc., where livestock are more likely to experience stress would be useful when developing strategies for reducing stress, death losses and improving the welfare during transport.

8.4.1. Scope

This sub-theme will focus on creation of knowledge of different space requirements, transport durations, models of transport vehicles etc. to be used during transport to optimize the welfare of animals under Sri Lankan conditions.

8.4.2. Objectives

- To study the space requirements, effect of duration of transport (including requirements of rest, feed, and water during transport) and vehicle designs during transport for Cattle, Buffalo, Pigs, Goats, Sheep and Chicken.
- To examine the currently adopted criteria on space, provision of adequate feed and water, cleanliness and proper ventilation during transportation and to formulate guidelines using outcome of these studies and available literature.

8.4.3. Expected outputs

- Guidelines on livestock transportation will be formulated and made available to safeguard livestock from being stressed and injured during transportation.

8.4.4. Research needed to achieve the expected outputs

- Duration effects - Effect of different transport durations (distance and time) on welfare of Cattle, Buffalo, Pigs, Goats, Sheep and Chicken under Sri Lankan conditions (including requirements during long distance transportation).
- Animal density effects (space during transportation) - Effects of different stocking densities on welfare of animals during transportation.
- Vehicle effects - Effects of different vehicle designs and driver effects on welfare of animals during transportation.
- Effects of handling prior to, during and post transportation.

8.5. Sub-theme II: Study the effects of environment and housing on welfare of livestock

8.5.1. Scope

Proper housing and management facilities are essential to animal welfare. A good management facility provides environment, housing, and care that permits animals to grow, reproduce and maintain good health. Research throughout the livestock industries has shown that animals showing poor physical and/or mental health can have lower reproduction, growth and production rates. This sub-theme will focus on creation of knowledge of different housing and environment requirements of livestock to be used in management to optimize the welfare of animals under Sri Lankan conditions.

8.5.2. Objectives

- To document current welfare standards of livestock in Sri Lanka (Cattle, Buffalo, Pigs, Goats, Sheep and Poultry).
- To formulate recommended guidelines using outcome of studies conducted on this regard and available literature.

8.5.3. Expected outputs

- Current welfare standards of livestock in Sri Lanka will be identified.
- Guidelines on housing and environment of livestock will be formulated and made available to safeguard livestock from being stressed.

8.5.4. Research needed to achieve the expected outputs

- Heat stress, ventilation and air quality effects on welfare of animals.
- Adequate housing designs to minimize pain and discomfort to promote optimum behaviour of animals.
- Effects of management aspects on rescued and stray cattle and buffalo in animal shelters.

8.6. Sub-theme III: Socio economic factors affecting welfare of animals

8.6.1. Scope

The management of farm animals has changed significantly across the world over the past five decades. Many studies show that consumers are concerned about the welfare of farmed animals, and this in turn has led to an increased public demand for stricter welfare standards in farming and is evident by the increase in policy debate and the introduction of new legislation. The scope of this theme is to understand how consumers, producers, and the global community perceive animal welfare issues with respect to animal husbandry in Sri Lanka, and to discuss the potential impact of the resulting attitudes that may influence the development of animal husbandry in Sri Lanka.

8.6.2. Objectives

- Investigate the attitudes of general public with respect to animal welfare, socio economic factors affecting slaughter practices in Sri Lanka, and global perception on farm animal welfare in Sri Lanka.
- Identify barriers to implement animal welfare laws in Sri Lanka.
- Study the feasibility of issuing certificates based on animal welfare standards to producers.

8.6.3. Expected outputs

- Attitudes of general public with respect to welfare of animals will be identified.
- Socio economic factors affecting slaughter practices in Sri Lanka will be identified.
- Global perception on welfare of farm animals in Sri Lanka will be identified.
- Barriers to implement animal welfare laws in Sri Lanka will be identified.

8.6.4. Research needed to achieve the expected outputs

- Identification of ethics and attitudes of general public with respect to welfare of animals.
- Religious beliefs and taboos with respect to animal welfare.
- Socio-Economic aspects with respect to animal welfare.
- Level of awareness regarding animal welfare.
- Socio economic factors affecting slaughter practices in Sri Lanka.
- Global perception on farm animal welfare in Sri Lanka.
- Identification of barriers to implement animal welfare laws in Sri Lanka.
- Study the feasibility of issuing certificates based on animal welfare standards to producers.

9. References

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10. List of Participants at the Workshop held on 17th June 2016

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