REPUBLIC OF RWANDA

Ministry of Agriculture and Animal Resources (MINAGRI)

STRATEGIC AND INVESTMENT PLAN TO STRENGTHEN THE ANIMAL GENETIC IMPROVEMENT IN RWANDA

FINAL REPORT

AUGUST 2012

Table of content

0. Introduction 1
0.1. Livestock production in Rwanda 1
0.2. Livestock policies and strategies in Rwanda 2
0.3. Stakeholder capacity and on-going genetic improvement 3
0.4. SWOT for AGI in Rwanda 4
0.5. The purpose of the strategic genetic plan 5
1. Actual situation of Genetics and Husbandry 6
1.1. Honeybees 6
1.2. Aquaculture 9
1.3. Rabbits 11
1.4. Poultry 13
1.5. Pigs 15
1.6. Small Ruminants 17
1.7. Cattle 20
1.8. Analysis and evaluation of AGI programs in place 22
2. Genetic Improvement 25
2.1. BEES 25
Organizational aspects of the sector 26
Institutional aspects 27
2.2. AQUACULTURE 28
2.3. RABBITS 31
Organizational aspects of the sector 32
Institutional aspects 33
2.4. POULTRY 34
Organizational aspects of the poultry sector 36
Institutional aspects 36
2.5. PIGS 37
General 37
Breeding 38
Organizational aspects of the sector 40
2.6. SMALL RUMINANTS 42
Organizational aspects of the sector 44
Institutional aspects 44
2.7. CATTLE 46
Organizational aspects of the sector 50
Institutional aspects 50
2.8. CROSS CUTTING ISSUES 52
Genetic conservation 52
Research, training and extension 54
2.9. Organizational aspects to facilitate AGI 59
2.10. Livestock in poverty eradication 61
2.11. Legislation for AGI 62
3. Strategic options for animal genetic improvement 64
3.0. Overview 64
3.1. Baseline study and monitoring system 67
3.2. Research and Extension 69
3.3. Develop breeding plans 72
3.4. Organizational Development 78
3.5. Capacity building and participation 81

3.6. Conservation of animal genetic material 84
4. Logical Framework 87
5. ANNEXES 92
5.1. Annex 2: People met 92
5.2. Annex 3: Bibliography 96
5.3. Annex 4: Some additional information on genetic improvement in general and in Rwanda 98
Genetic improvement of animals in general 98
Different breeding schemes: 100
Genetic improvement in Rwanda in particular 102
5.4. Annex 5: Animal husbandry and some production and economic parameters, important for genetic improvement 104
Introduction 104
Beekeeping 104
Fish farming 106
Rabbits 108
Poultry production 109
Pig production 111
Small ruminants 112
Cattle 113
Some cross-cutting animal husbandry issues 114
Common cross-sectorial issues for the livestock sector in Rwanda 114
Pigs 118
Small ruminants 118
Cattle 118
5.5. Annex 6: Quick analysis of the implementation of the 2007-2012 beekeeping strategy 121
Annex 7: Cost estimate for the running costs of a pig AI station with 10 boars 123

List of Figures

Figure 1: a bee stable of a cooperative with mainly traditional hives 8
Figure 2: Integrated fish-rabbit production 12
Figure 3: young breeding boars of undetermined genetics ready for sale 16
Figure 4: traditional fat tail sheep 19
Figure 5: Goats for sale on a village market 19
Figure 6: Typical Holstein (imported) 21
Figure 8: F1 Ankole Jersey? 21
Figure 7: F1 or F2? Ankole-Holstein 21
Figure 9: Inyambo 21
Figure 10: a schematic overview of pig production value chain 37
Figure 11: crossing scheme for production of slaughter pigs 38
Figure 12: imported wool sheep: Merino? 45
Figure 13: Girinka beneficiary (cow not in lactation) 51

List of Tables

Table 1: self-sufficiency for milk and meat 2
Table 2: SWOT for AGI in Rwanda 4

Table 3: SWOT for beekeeping in Rwanda 6
Table 4: SWOT for aquaculture in Rwanda 9
Table 5: SWOT for rabbit keeping in Rwanda 11
Table 6: SWOT for poultry production in Rwanda 13
Table 7: SWOT for pig production in Rwanda 15
Table 8: German Butcher 16
Table 9: SWOT Small Ruminants 17
Table 10: SWOT Cattle 20
Table 11: Strategies for bees 25
Table 12: Strategies for fish 28
Table 13: Strategies for rabbits 31
Table 14: Strategies for poultry 34
Table 15: Strategies for pigs 38
Table 16: Strategies for small ruminants 42
Table 17: Strategies for cattle 46
Table 18: Some parameters needed to calculate feed margin (many still unknown) 107
Table 19: Number of pigs in Rwanda (*1000) 111

Abbreviations

APEL	Programme d'Apui au Petit Elevage
ARDI	Rwanda Association for the Integrated Development
ASF	African swine fever
EAC	East African Community
EDPRS	Economic Development and Poverty Reduction Strategy
EU	European Union
F1	First generation crosses (term in animal breeding)
FAO	Food and Agriculture Organisation of the United Nations
FMD	Foot and Mouth Disease
HCC	Honey Collection Centre
ICAR	International Committee for Animal Recording
ISAE	Institut Supérieur d'Agriculture et d'Elevage
ISO	International Organisation for Standardization
LCB	Local Capacity Building
MCC	Milk Collection Centre
MINAGRI	Ministry of Agriculture and Animal Resources
MOU	Memorandum of Understanding
NGO	Non-Governmental Organisation
NABRC	National Animal Breeding and Registration Centre
NVD	Newcastle Viral Disease
P	Parent (generation: term in animal breeding)
POL	Point Of Lay
PUM	Dutch Program for Retired managers/specialists in dev. assistance
RCA	Rwanda Cooperative Agency
R&D	Research and Development
RBS	Rwanda Bureau of Standards
RWF	Rwandan Franc
SNV	Dutch Development Organisation
SPS	Sanitary and Phyto Sanitary measures
RFID	Radio Frequency Identification
TA	Technical Assistance
TOR	Terms of Reference
TOT	Training of Trainers
UHT	Ultra High Temperature (treated milk)
WHO	World Health Organisation

Executive Summary

This report is divided in three parts: in part one an overview is given of the status quo of the livestock sector in Rwanda in terms of husbandry and genetics. Part two describes how animal production can be improved through a combination of interventions in the husbandry system and the genetic composition. Part three gives an outline how the proposed interventions can be implemented and what the indicative consequences for the budget are. In annex 4 some additional information about genetic improvement is given for those not familiar with the subject, with a number of specific references to Rwanda. Annex 5 gives a more generalized overview of animal production and genetic improvement in Rwanda, whereby the importance of increased economic returns is stressed: without economic profitability of production farmers will be less inclined to invest in genetic improvement.

Livestock production improvement can only be achieved if and when simultaneously both the genetic composition of animals and the management in which they are kept are improved. Just concentrating on genetic improvement will not bring the required production improvement and increased farmers' income. Also the development of value chains and final markets are important to add value to the primary product and prepare it for the market demands. The country should develop an integrated animal production development strategy, in which genetic improvement is only one part of an all-compassing vision and strategy to uplift the livestock sector.

In annex 4 the different breeding schemes are explained. Crossbreeding is an important strategy for animal production improvement, but needs a constant supply of purebred parent stock to continue the crossbreeding scheme in case of a terminal cross (the product of the crosses F1 is not used for further reproduction). Rwanda does not have schemes for registered pure breeding and this makes it difficult to maintain purebred populations of animals and execute selection activities within these populations to improve. A strong point is made that in any crossbreeding programme there should be a clear description and plan what the purpose of the crossbreeding is and how it proceeds after the first generation (F1). Rwanda will have to develop registered purebred nuclei for the most important breeds required for the breeding strategies and or import semen (Holstein, Jersey, Sahiwal, Boran) to be used in the crossbreeding programmes envisaged.

Besides the perceived need for genetic improvement as a priority for the improvement of livestock production there are more pressing needs in the area of developing more and better feed and fodder resources and controlling animal diseases. FMD and lumpy skin disease severely affect the productivity of cattle and are regularly re-occurring. There is an imminent threat of PPR for small ruminants, which will have devastating effects on the production of these species. In pigs ASF is a constant risk, especially near the forest areas with wild pigs, which serve as a reservoir. In poultry NDV can cause heavy losses. It is beyond doubt that improvements in feed and animal health will result in larger livestock production increases in the short term than genetic improvement and should be considered priority.

A SWOT analysis is given of the Rwanda livestock sector. One of the strengths is the keen interest of the people in keeping livestock, a great opportunity is to channel this interest into active participation of livestock farmers in animal genetics improvement programmes, which can executed through village farmer groups. Weaknesses are the lack of forage resources and the low profitability of especially milk and pork production. In the genetic field the major weaknesses are the lack of a good animal identification and registration system and the low level of knowledge of current production potential of animals under the prevailing conditions. Opportunities can be found in involving the private sector in livestock improvement and to make livestock genetic improvement an integral part of overall strengthening of livestock value chains: without profitable marketing and processing channels increased production at farmer level will not result in increased income for farmers. Some of the threats to the Rwandan livestock sector identified are the at times little planned introduction of new genetic material with too little research and follow up and the narrow genetic basis of such introductions. In the absence of a clear breeding plan such introductions in many cases have disappeared within the traditional population (e.g. pig-, poultry-, and goat introductions in the past)

In part 1 the various livestock production farming systems are being described. Special attention is paid to the financial aspects of the different production systems, through which it can be seen that both pig and milk production have currently profitability constraints. Genetic improvement costs money and should lead to increased revenue to justify this investment. Currently there are few real beekeepers in Rwanda: most are 'honey harvesters' and manipulation with queens etc. is a step ahead: first people should learn the basics of beekeeping, modern hives and then the issues of queen management can be introduced. Fish farming is relatively new in the country and a top priority is to secure the provision of fingerlings after the end of the project and to create a value chain to absorb the immense increase in production foreseen. In poultry the presence of quality affordable feed is paramount for the profitability of any poultry activity other than keeping free-range birds. The country does have facilities for the multiplication of commercial bird 'brands', but run by government and currently not sufficient to provide the local market demand; imports from neighbouring countries have had mixed results. There is no provision for the breeding of the poultry 'breeds' and the mini hatcheries could play a role there. Pig husbandry as said is at the moment not profitable if fed commercial poultry feed and the current system is improved scavenging with pigs being fed left overs from bananas, elephant grass with some bran supplementation. Only with improved marketing facilities and prices this situation will change. Small ruminants are increasingly kept in confinement and play a growing role in the meat provision. There are interesting experiences with dairy goats, which should not be ignored as an alternative to dairy cows for resource poor farmers. In the cattle sector there are the grazing animals of Ankole, mixed and Holstein breeds and the zero-grazed animals. It seems that at the moment beef production is more profitable than the dairy production and the dairy value chain will have to be improved to make dairying more interesting. To capture both dairy and beef as products this strategy suggests practicing a criss-cross between a Zebu breed for adaptability

and meat without losing milk production capacity (Boran or Zebu) and a Taurine (Holstein or Jersey) to maintain the dairy production capacity.

The genetic composition is described and a point is made that local genetic resources are in most cases the best in unimproved environments. It needs careful analysis and research to come to the right conclusions how to improve the genetic basis of the livestock in the country. In the case of non-improvement of the environment in which animals are being kept the introduction of or crossing with exotic breeds is not advisable.

Part two gives recommendations per species on how the production and productivity can be improved, not only through genetic improvement, but also especially by improving the animal husbandry and the service delivery to farmers. The public private collaboration can be improved by forming working groups per species, leading to specific action by both to improve the sector. MINAGRI and RAB have to work towards a more connected and holistic approach towards the livestock sector and phase out the sectorial and short-term thinking.

Part three gives an overview of how the individual actions per species towards improvement can come together in new structures, approaches and procedures. Genetic improvement should be accompanied by a rigorous recording of animal data. Performance testing should become an integral part of the livestock production sector so that in the long run a system of genetic improvement based on local selection and selective breeding can be set up. For this to happen farmers will have to organize themselves in breeding groups/associations and herd/flock books.

The role of government is to guide the process and especially in developing the animal identification and registration system, which is the core of a genetic improvement programme. Without performance testing there can only be controlled reproduction, which is not really genetic improvement through selection in the own populations, but making use of imported results of selection elsewhere (import of animals/semen).
Well described breeding plans and breed standards should guide people in doing on-farm selection and contributing towards the development of the breed. Community livestock breeding groups have been proven elsewhere to be effective instruments to improve the genetic quality of livestock.

The three main strategic options of this animal genetic improvement strategy are:

- Develop improved understanding of actual production and genetic potential and monitoring system to measure on-going and future improvement
- Increased human capacity for research and extension in, services to improve and management of animal genetic resources
- Private sector driven and managed breeding plans with the government in a regulating and support role

First part: Actual situation of animal husbandry and breeding in Rwanda

0. Introduction

0.1. Livestock production in Rwanda

Rwanda is the most densely populated country in Africa with limited land resources. It cannot further expand its agriculture through increase in the area under crops. Intensification seems to be the only remaining option to increase the overall production. The available grazing area for both game and livestock has decreased considerably over the last 20 years and so have the areas under forest due to an increased area under crops. The government acknowledges the inherent risks of erosion, lack of firewood caused by the heavy population pressure and intensive land use. Through intensive programmes it works on the rehabilitation of degraded lands, reforestation, terracing and regulation of the drainage of bottomlands to enable rice cultivation and fish production. Livestock has always been part of the Rwandan farming systems, whereby the pure pastoral production systems have slowly but surely been replaced by sedentary mixed farming systems. Livestock plays a key role in the above-mentioned intensification of production and increased value addition to crops, crop residues and grazing resources.

The government has acknowledged livestock as an important part in achieving food security for Rwanda, especially in terms of the protein requirements and also its potential role in poverty alleviation. MINAGRI is leading the national efforts to initiate, develop and manage suitable programmes for the transformation and modernization of agriculture and animal resources. Livestock is seen as a key pillar for economic growth, poverty reduction as described in the EDPRS. The challenge remains to design and develop the livestock production systems in such a way that they can contribute to both food security and poverty alleviation, especially in the smallholder sector, without leading to environmental degradation. Genetic improvement is only one of the many contributing factors to increased livestock productivity and production and with improving the nutritional status and health status of animals one of the key factors for this improvement in livestock production.

The brief of this consultancy was to look into the genetic aspects of livestock production and develop a strategy and investment plan (see annex 1 for TOR). These genetic aspects are closely linked to the economic aspects of livestock keeping, as farmers' prime objective is to make money with their animals. For this reason in annex 5 the key husbandry aspects and the current key economic parameters as far as known will be briefly mentioned per species. Consultant

feels that genetic improvement can only be effective if all husbandry aspects are also taken care of.

0.2. Livestock policies and strategies in Rwanda

In Rwanda a number of key policies have been put in place (Vision 2020, the Economic Development and Poverty Reduction Strategy 2008-2012, Agricultural Development Policy (PSTAII) and various sectorial strategy papers), which determine the development's direction of the country's economy, agriculture and livestock sector within the overall economic development process. The main goal of the Vision 2020 is the transformation from subsistence to a productive, high value, market-oriented agriculture that acts as a catalyst for further economic development in processing, trade and releasing people from the agricultural sector into other sectors of the economy. Key products for this policy are milk, meat, fish, hides and skins and honey.

In this context, the Ministry of Agriculture proposed an agricultural policy, which consists of four main objectives:

(i) The modernization and transformation of Agriculture;
(ii) The development of important commodities;
(iii) Competitiveness of the products on the market;
(iv) High entrepreneurship capacity of the farmers.

The result should lead to both poverty reduction and achieving food security; farmers should increase their income in an environmentally sustainable way. The country has set targets for consumption per capita, with which the required production can be calculated. According to WHO the minimum per capita annual requirement for milk is 220 litres, while that of meat is 50 kg. At the moment Rwanda produces 12 litres of milk and 4.8 kg of meat per capita per year, which does not guarantee that everybody has a chance to even consume this low quantity or that it is all available for the local market, as there is also export to neighbouring countries. One should however keep in mind that food security is not the same as food self-sufficiency. The FAO defines food security as a condition that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern.

Table 1: self-sufficiency for milk and meat

Following the WHO/FAO recommendations for annual milk and meat consumption per capita and an estimated population living in Rwanda of 10 million the current gap for milk amounts to $2.08*10^9$ liter milk and $452*10^6$ kg for meat. It is obvious that self-sufficiency for milk and meat will be extremely hard if not impossible to achieve.

0.3. Stakeholder capacity and on-going genetic improvement

Any strategic planning would have to be cognizant of the current state of genetic improvement work and the capacity of all involved in terms of knowledge, skills, means and finance. Consultant formed an idea of this by visiting livestock development centres, discussions with officials at national and provincial level and encounters with many farmers.

There are roughly two types of livestock keepers:

- Those living on the farm with their animals
- Those living away from the farm and leave the farm to manager

The keepers living on-farm are usually mixed farmers and have various other agricultural activities. In most cases their animal husbandry system is traditional. This applies to most poultry, cattle, goat and sheep keepers. Animal Genetic Improvement (AGI) requires a certain level of husbandry practices, which in many cases has not been reached. This refers to feeding and health care of animals so that they can express their genetic potential, but also in knowledge of reproductive cycle, heat detection and choice of the right genetics to mention a few aspects, which need working on before AGI will become effective. In the case of fish farming, beekeeping in modern hives, commercial poultry production, commercial pig production and dairying individual farmers have still much to learn before they are able to reach maximum returns on animals present, leave alone with more demanding animals of higher genetic potential. Concurrent with AGI there has to be a major effort in improving general animal husbandry practices and safeguard animal health.

Farms with an absent owner visited all show exactly the absence of the eye of the master to put the finishing touches and keep the general overview. Production is average; managers are often faced with situations in which they cannot solve the issue due to lack of equipment, finance and/or finance. Some farms are started and stop after 1 or 2 years, especially with commercial pig and poultry production, others continue with little progress. Dairy farms under a manager and absentee owner resort to milking off grass, usually run a bull with the herd as the easiest way to get the cows in calf again. Ways have to be found to develop alternative management structures or management support for such farms to gain maximum benefits from them and to make AGI possible.

Technical officers in districts have good technical knowledge, but often lack the means to reach farmers and/or have too many farmers under their responsibility to build up a working relationship with them. In many cases their knowledge is limited to the technical issues and they find it hard to place the required interventions into a larger framework of the farming system. Specific places and situations require specific approaches and solutions to problems; too often the blanket recommendation approach is what is being applied. In many cases the value chains are poorly developed (fish farming has to be build, dairy high interaction costs, pigs only few outlets with oligopolistic tendencies etc.). Reports from MINAG staff monitoring distributed improved animals in the

context of AGI often don't find the animals back or under traditional management practices, in which the superiority cannot be shown.
AI results are not objectively measured and analysed. There is therefore a great discrepancy between what inseminators tell as success rate, the ministry reports and the farmers claim as the success rate. The evaluation of Girinka shows that only a fraction of the distributed cows is actually producing milk: a combination of low calving rate, lack of sufficient quality feed, all results of a combination of farmers not yet capable to keep such animals and extension workers not able to turn the tide around.

These are just a few examples to indicate that there is still a lot of work to be done for AGI to be converted into additional income for farmers (this would in the case of e.g. dairy cows take 33-40 months anyway due to the generation interval). Only with an integrated approach to improve and management, animal health and the genetics, together with guaranteed markets with commensurate prices will animal productivity and production pick up.

0.4. SWOT for AGI in Rwanda

From the above and further observations the following SWOT analysis with an overview of the on-going work in the field of animal genetic improvement in Rwanda has been prepared.

Table 2: SWOT for AGI in Rwanda

STRENGTHS - Livestock keepers have great affinity with their livestock - Presence of an animal population, which genotype is well adapted to prevailing conditions - Highly motivated government professionals at the service of farmers - Government cognisant of the importance of genetic improvement and ready to further invest in it - Existing infrastructure and capacity for selection and reproductive work	WEAKNESSES - No underpinning of genetic improvement work with result monitoring and economic parameters - Little to no involvement of private sector in genetic improvement - Poor animal identification system and no performance testing - Poorly developed value chains in the livestock sector, preventing specialization among farmers and private investment in trade and processing due to high level of "informal trading" - No clear link between genetic improvement work on station and the realities in the field -
OPPORTUNITIES - Interest and involve livestock keepers to do animal selection and genetic improvement themselves - Involve the private sector in animal genetic improvement and breeding as gene fond - Develop an animal registration system, linked to performance testing and selection - Develop integrated value-chain development plans in which genetic improvement is part of a larger total improvement plan to increase impact and returns	THREATS - The narrow genetic base of the genetically improved animals due to "loss" in cross-breeding and lack of registration and recording - Environmental limitations (esp. animal nutrition) hindering the expression of genetic potential - Too little economic benefits for national economy and farmers from the current genetic improvement programme to justify the investments - Introduction of new breeds/varieties before these have been thoroughly tested for suitability under Rwandan farming conditions

0.5. The purpose of the strategic genetic plan

The purpose of the strategic plan is stated in the TORs as follows:

> "To contribute towards improving the efficiency/productivity of the animal resources subsector in a sustainable manner, promote public health and support marketing of both livestock and livestock products to contribute to the national efforts in poverty reduction, improved food security and income to the satisfaction of the expectations of key and subsidiary stakeholders".

Each section on a particular animal species in this paper consists of 3 parts:
First part- status of husbandry system and genetic improvement in Rwanda: This is a status report of animal genetic improvement for that species, but also a description of the environment in which animals produce and are being kept, its opportunities and shortcomings.
Second part: The main strategic orientations (technical, organizational, institutional) and crosscutting issues (finance, R&D, environment, gender): a description of the various development opportunities and the way in which selection and genetic improvement can be embedded in these.
Third part: Actions proposed. The sum total of these actions has been aggregated in a *Logical framework for the operationalization of the strategic plan:* in this last section of the report the various interventions suggested in the section per species have been grouped in cross-species interventions, divided in short-term, medium term and long-term.

1. Actual situation of Genetics and Husbandry

1.1. Honeybees

Table 3: SWOT for beekeeping in Rwanda

STRENGTHS - Good domestic and regional market for honey - 3 specific key areas for honey production available in the country with specific product characteristics - Established network of producers' organizations and links with regional markets - Long tradition in both people and government structures to deal with bees	WEAKNESSES - Most people involved in bees are honey harvesters and not yet professional beekeepers - The capacity of the extension services is not capable to guide the cooperatives and associations, especially in financial matters - Commercial traders have undermined the envisaged cooperative character of the sector - Too little information on productivity and carrying capacity of the various zones of the country
OPPORTUNITIES - Build the skill levels of those involved in bees to become true beekeepers, who can e.g. work with queens - Develop the local manufacture of Langstroth hives and beekeeping equipment as a SME activity - A further increased involvement of women in beekeeping, breaking old habits and taboos - Develop an integrated community based forestry management plan, in which the beekeeping forms an integral part to avoid future conflicts between conservation and exploration of forestry resources	THREATS - The current mode of honey harvesting leads to a high % of deserted hives, reducing production - Beekeeping and Natural Resource management are at loggerheads about forest fires and poaching by the honey collectors/beekeepers - The conversion of forest and savannah into crop and grazing lands reduces the carrying capacity - Diseases such as Varroa, American Foul Brood and Sudden Colony Collapse - Keeping bees in populated areas leads to conflicts between beekeepers and non-beekeepers

Introduction

The first interventions in the beekeeping sector were initiated by government in the eighties, after which ARDI (Association for promotion of Integrated Development in Rwanda) entered into a MoU with the government in 1991 for 11 years to take charge of the beekeeping sector. In this period the introduction of modern beekeeping was intensified. In 2002 beekeeping was selected as a not land liked production system, with active promotion by government as provider of employment. A number of beekeeping collection centres (HCC) was built, which were eventually converted into beekeeping cooperatives by the RCA (Rwanda Cooperative Agency).

A number of NGO's became active in the beekeeping sector:

Nyungwe	ARDI
Akagera	SERUKA
Gishwati	ADEPE
Virunga	REDDO
SNV	a sector and country wide role in business development, using the Above organizations as Local Capacity Builders (LCBs)

Where initially most of the commercialization of the honey was taken care of by the NGO's involved, which led to a certain amount of dependency of the beekeepers on "their" NGO to sell, this has gradually changed into the cooperatives having to take up this task. This led to the formation of a number of umbrella sales organisations for the cooperatives (CESAPI, UNICOOPAV). The cooperatives have however problems to meet the RBS (Rwanda Bureau of Standards) requirements, which is necessary before being able to sell into Kigali and other urban centres. Nobody seems to have attempted to register with the Fair Trade Honey Register in Bonn (http://www.fairtrade.net/honey.html) and explore the export markets, for which compliance with OIE rules as the holders of the SPS measures for products of animal origin (http://ressources.ciheam.org/om/pdf/b25/99600247.pdf and http://www.oie.int/index.php?id=169&L=0&htmfile=titre_1.9.htm). For this to happen better tracking and tracing, branding and product quality control would be necessary.

The beekeepers in Rwanda can be divided in 3 categories:

1) *Semi-professional*, dedicating 40-60% of their time on beekeeping. This is the target group of the government programmes for the promotion of not-land linked production systems through the BRD (Rwanda Development Bank) and mainly in the 4 key beekeeping areas;
2) *Side-line production system, farmers* keeping some hives for some additional income, but not investing much time or money in this activity;
3) *Hobbyists,* keeping 2-3 hives for own use, relatives and friends.

In general it can be said that the majority of the beekeepers in Rwanda are over 40 years old: so far the drive to develop beekeeping as a job creating activity has apparently been slow. In 2006 SNV called all stakeholders together and initiated the process of the formulation of a National Beekeeping Strategic Plan 2007-2012. A number of actions and interventions were planned, but not all were executed. Although the strategic plan was and still is a commendable sector initiative it lacked in clear indications that would do what, how, where and within how much time. The end result is that everybody continued with his/her activities as best as he/she could. There is now need for strong guidance and facilitation of this group of organisations and structures all with the best intentions for the sector to institutionalize their collaboration, collect data, analyse and update the strategic plan for 2012 till 2017. An analysis of this strategic plan and its implementation can give valuable recommendations for future strategic plans (see annex 4).

Bee genetics

In the field of genetics it is clear that in the past with exclusively honey harvesting/hunting most honey collectors would leave the most aggressive bees alone, which means that they had/have the best chance to survive, multiply and swarm and occupy empty hives; the more docile bee colonies were and still are preferred for honey collection and were and are thus more disturbed and/or destroyed than their aggressive brothers/sisters. This management practice might over the years have led to a negative selection for more aggressive bees colonizing the traditional hives in the forest zones. This is however hard to

prove. Without active hive management and production recording it is unlikely that any selection by humans in the bee genetics has taken place in the past.

Genetic selection in bees is usually geared towards 3 criteria:

- Production of the colony;
- Aggressiveness;
- Tendency to swarm.
-

All of these characteristics have a relatively low hereditability and are hard to objectively measure. It is very likely that in Rwanda there are 3 distinct different "breeds" or ecotypes of the African honeybee:

- the Nyungwe lowland forest type;
- the Virunga highland forest type;
- the Akagera African savannah type.

These bees have through natural selection adapted to their environment and are probably unbeatable in terms of their genetics and suitability for the area where they were selected. The current waves of sudden colony collapse in the USA and Europe are a worrisome phenomenon, which is still attributed to use of pesticides, the presence of Varroa, but can also well be a result of too little natural resistance to adverse conditions, results of too one-sided selection for production in the Carnina bees? With the advent of Varroa in Rwanda selection should be for those colonies least affected by Varroa, showing resistance, a good production, low tendency to swarm and limited aggressiveness. In South Africa beekeepers working with Langstroth hives have increasingly problems with theft of complete hives and have resorted to selecting for more aggressive bees to make life harder for thieves[1].

The above shows that only in consultation with the actual beekeepers a selection strategy can be developed, which suits the farmers and their specific conditions.

Figure 1: a bee stable of a cooperative with mainly traditional hives

[1] pers. Comm. Mike Allsopp ARC South Africa

1.2. Aquaculture

Table 4: SWOT for aquaculture in Rwanda

STRENGTHS - Rwanda has sufficient water sources to keep fish ponds full - Suitable sites for fishponds on the lower slopes of valleys - Rwandans traditional fish eaters and fishermen - Presence of smallstock to integrate with the fish farming - Presence of 3 hatcheries in the country	WEAKNESSES - PAIGELAC and other aquaculture projects without a clear exit strategy - Too little experienced extension workers to monitor the large number of new ponds - Start up of fish farming under grants, hard to see how fingerling business will develop - Fish feed manufacturing not developed
OPPORTUNITIES - Develop value chain with cold chain and processing plant for fillet production - Incorporation of Tilapia fillet in supermarkets and export in regional markets - Collaboration with SE Asian specialists with superior knowledge and experience - Exchange visits to SE Asia	THREATS - Hatcheries not able to run as commercial enterprises without outside support - Uncontrolled import of fresh fish from neighbouring countries - Limited biodiversity in fish stocks carries a risk for disease outbreaks

Introduction

Fish farming is the most efficient way of producing animal protein, with feed conversion of below 1.5 (chicken 2, pig 3, ruminants 5-10). With the possibility to integrate fish farming with small animal production (rabbits, poultry, pigs, goats/sheep) and using the effluent to irrigate vegetable plots, thus serving as source of fertigation and a water storage buffer in case irrigation water finishes (without jeopardizing the fish of course) it is commendable that the government through its various programmes promotes the construction of ponds and builds the capacity for fingerling and fish feed production.

Fishery has been traditionally the main source of fish for the Rwandans; fish farming/aquaculture is a relatively new concept in the country. Uncontrolled access to the lakes, use of illegal and destructive gear and overfishing reduced the useable fish stock and thus the annual off-take of fish from the lakes. Extensive studies to improve the fish stocks in natural lakes through reduction of the quantity of predatory fish and restocking were done under the PAIGELAC and specific management plans were drawn up (see the BCEOM reports). These interventions were combined with the (re?)Introduction of *Tilapia nilotica*.
With the high level of illegal fishing of the past it is hard to assess the volume of the annual catch. Estimate of the highest production recorded is 9.050 tonnes of fish valued at USD25 million. Consumption of fish per capita in Rwanda is 1kg, whereas in Burundi 3.6, DRC 6.9, Uganda 10 and Tanzania 11.9kg/year (PPP Dr. Wilson RUTAGANIRA). This shows that there is a potential market for the fish production in-country.

Aquaculture in the bottomlands is being promoted by the PAIGELAC project and the Kigembe fish hatchery plays an important role in the provision of fingerlings. There are currently around 800 ha of fishponds in Rwanda[2].
The aquaculture is practiced in a subsistence low external input way. Ponds are fertilized with rabbit, chicken and/or pig manure or compost. There is little pond management and with the breeding habits of Tilapia the fish will be many but of a small size. Aquaculture is in most cases a new venture for both the farmers and the advisory services of RAB. It will be a learning curve for both to achieve the best results.

Commercial fish feed with a protein content of 40% is expensive to produce. Rwanda is importing more than 11.000 tonnes of dried fish from Uganda and Tanzania annually. This fish also plays an important role in the manufacture of poultry and pig feed and at the time of this study was trading for around USD 800/tonne. With the projected 16 million people by 2020, the country will need 112,000 tons of fish annually if the population is to catch up with the current average fish consumption in Sub Sahara Africa.

There is a great gap between the strategic plans, feasibility studies and the realities on the ground: many elements to make it all work are still missing, such as a vibrant private sector to handle the following elements of the value chain:

- Commercial fish hatcheries for the planned production of sufficient fingerlings to stock all fish ponds, cages and if necessary lakes;
- Fish feed manufacturers[3];
- Dedicated fish farmers with sufficient knowledge, skills and means for commercial fish production;
- Extension/advisory services (public/private)
- Cold chain operators (transport and storage);
- Filleting and packaging plant;
- Traders.

Genetics
Aquaculture in Rwanda mainly concerns *Tilapia nilotica*. In phase I of PAIGELAC programme *T. nilotica* from Lake Albert was brought to restock some lakes in Rwanda. For the aquaculture similar Ugandan *T. nilotica* has been imported. Little to nothing is known about the indigenous Tilapia genetics, nor has the Ugandan *T. Nilotica* been compared with e.g. Hybrid Tilapia or GIFT[4] lines from South Asia. There is need to develop a more systematic programme for "provenance" testing of the various Tilapia lines and breeds and identify and select the best variety for Rwanda.

[2]pers. Comm. Stefanie KAMUNDO of RAB
[3] PAIGELAC procured 8 units to produce fish feed, but will have to find entrepreneurs to run these
[4] Genetically Improved Farmed Tilapia

1.3. Rabbits

Table 5: SWOT for rabbit keeping in Rwanda

STRENGTHS - Highly prolific and capable to produce large numbers of breeding animals during a short time - Cheap to keep: Local resources sufficient for optimal production - An easy source of small cash for a family, especially women and children	WEAKNESSES - No mechanisms for exchange of genetics, possibly leading to inbreeding - No sector organization or structure to take care of the above
OPPORTUNITIES - Integration of rabbit production in school curricula and programs - Promoting "pass on the gift" programmed to supply rabbits to poor families - Utilization of pelts for manufacturing -	THREATS - In case of poor hygiene diseases can wipe out the rabbit stock (e.g. pasteurellosis) - Rabbits are susceptible to predators and dogs and theft - -

Introduction

The colonists and missionaries introduced rabbits into Rwanda. Schools with school rabbitries played a role in the promotion. They provided school children with rabbits to take up rabbit production at home. There used to be three FAO run smallstock centres in the north, centre and south of the country. None of these are functional anymore and any documentation about these centres was lost during the war. These were the main source of breeding stock in the past. Most rabbits kept in Rwanda are of a California-New Zealand often crossbred type. The often occurring drop in productivity after 1-2 years is perceived as inbreeding, but could be very well the result of build-up of pathogens, lowering of attention paid to the rabbits, especially when an initiated rabbit project progresses for a few years. It is however not established whether that is really from inbreeding or lack of supervision and monitoring after a project finishes.

Adult rabbits will consume between 400 and 500 gram of vegetable material per day and would do best if they received 40-50 gram of a more concentrated feed besides the green material. A still often heard misconception is that rabbits don't need water. Simple water containers can be made out of some cement and cut off plastic bottles. Training on improved feeding is required.

Rabbits are currently mainly distributed by NGO's working with poor families, AIDS orphans, and women groups. Most of these NGO's cannot find quality rabbits in commercial rabbitries in Rwanda and buy locally on the market or in some instances from neighbouring countries, where recent imports of improved genetic material were done.

All fishponds seen in Rwanda have rabbit hutches over them for the pond fertilization. This practice seems to be of mutual benefit: the fishes' provision of plankton and organic matter is increased and when the "bridge" to the hutches is removed there is less chance of theft. One of the main problems of rabbit keeping near houses is exactly the theft problem. People at times take rabbits indoors

during the night, but with young rabbits this causes too much stress and results in high mortality.

In general the various models of low-cost rabbit housing are well known and people can easily construct these.

Genetics

The most commonly kept rabbits are of a Californian-White New Zealand type. There is no registered pure-breeding and thus no chances to take advantage of heterosis by e.g. terminal crossing with a Flemish giant or even between reasonably pure lines of Californian and White New Zealand. At the moment the main issue raised by farmers is inbreeding, caused by the lack of exchange of genetic material between rabbit keepers and the absence of farms with genetically superior rabbits, where farmers could buy at times genetically improved animals.

Figure 2: Integrated fish-rabbit production

1.4. Poultry

Table 6: SWOT for poultry production in Rwanda

STRENGTHS - People have long experience in keeping poultry - Easy source of meat and cash within the family situation - Limited investments required to start a poultry business -	WEAKNESSES - Rwanda does have only limited capacity for the production of DOCs and depends largely upon imports - No feed mill and many feed ingredients need to be imported - Limited (commercial) poultry knowledge and experience in-country - No up to date knowledge of production potential of village chicken
OPPORTUNITIES - Establish a value chain with breeders and incubators - Exploit local varieties with premium prices commercially - Improve on disease control, especially NDV to increase production -	THREATS - Disease outbreaks, such as HPAI and NDV - Predators and theft - Dumping of import poultry meat and eggs

Introduction

The poultry sector in Rwanda can be divided in 3 systems:

- *The commercial poultry sector*: animals confined and 100% fed indoors with balanced ration. Genetic improvement in this sector has become over the years the exclusive task for a limited number of internationally operating poultry breeding companies. Their genetic products come with a "manual", in which the environmental conditions to get the highest returns from these animals, are being described. The only task left for the poultry farmer working with this material is to create the right environment according to the requirements under which these animals have been selected as being the most productive. As there has been a separate consultancy on the development of the commercial poultry sector I will not touch too much on this poultry sector in this report.
- *The semi-commercial poultry sector*: here improved breeds are kept under an improved scavenging poultry production system: semi-confined and fed with some commercial or home-mixed feed. It is in this sector that major production improvements can be made through genetic improvement of the animals in use. The recently started crossbreeding trials with the "Kuroiler" synthetic breed are an example of such a programme to study the possibilities to increase productivity of this poultry production sector. The historic cock exchange programmes attempted the same in the past.
- *The scavenging village poultry production system*: animals are non-confined and find the major share of their daily feed requirements themselves. Some kitchen waste is fed as supplement. Over the years there have been many programmes that distributed chicken to returning refugees and IDPs, some of them came back with chicken from the areas where they had lived. Through further cock exchange programmes the genetic composition is most probably quite different from the one always quoted in the literature of "4 clutches of eggs per year with 40-60 eggs produced".

It is unclear also whether there are sub-populations of particular genetic composition, which are superior to others. Better data collection on productivity and production in village poultry could give an insight. A major constraint in village poultry production is the high mortality of chicks during the first weeks and the occasional outbreaks of NDV, fowl pox and fowl cholera.

The government has a parent stock/hatchery/pullet POL production facility (Ruburizi), which produces layer and broiler chicks, but at a fraction of what is being imported on an annual basis into the country. It seems to be difficult to run an operation like that under government financial rules and availability of funds. There are now 4 mini-hatcheries in the country, of which some received support from APEL, operating with different rates of success. One is bankrupt. They don't have a very clearly defined role in the overall poultry sector and seem to have serious problems to keep their businesses going, both technically and financially.

If the government's strategic intake levels for consumption of eggs and poultry meat have to be met the production of poultry meat and eggs has to be drastically increased. There is also here export potential to DRC, which currently is filled through import-export trade, mainly from Uganda. To achieve this production increase the poultry feed situation will have to be drastically improved with competitive prices for the feed, followed by an increase of local chick production. The major bottlenecks for all 3 segments of the poultry sector is the absence of a reliable source of quality poultry feed for broilers, growers and layers, followed by the availability, quality and price of poultry drugs and vaccines.

Genetics

Since 1994 there have been many programmes to restock the family-farming sector with poultry: distribution of chickens, cock exchange programmes. Refugees came back bringing birds from neighbouring countries. It is therefore hardly likely that the existing village chickens are the same as the ones described in most of the literature as "laying 60 eggs per year in 4 clutches". It would merit an on-farm study to establish what the current production potential under traditional management (scavenging with some scrap feeding) is. It is well possible that there are regional differences and the best producing sub-populations should be identified and tested under similar environment to see whether the differences are because genetic or caused by favourable environmental conditions. There is no evidence that anywhere in Rwanda "breeds" of chicken are still being kept. Although these could play a role in the semi-intensive production systems there is no evidence that these are present in the country.

Commercial poultry breeding for both layers and broilers as earlier said has become the exclusive domain for a relatively small number of multinationals, selling through agents. There is no role anymore for individual farmers or government in commercial poultry breeding other than to from the technical specifications select the breed that is expected to give the best results under the prevailing conditions and the management level that can be provided. The only role is there for a number of parent stock keepers/incubators to produce the DOCs and in the case of layers a grower for the pullets till point of lay.

1.5. Pigs

Table 7: SWOT for pig production in Rwanda

STRENGTHS - Relatively easy animal to keep - Prolific and thus easy to spread good genetics out over many breeders in a short time - Traditional pigs can survive on crop residues and kitchen waste	WEAKNESSES - Sector unorganized - At the moment pork production for the market not profitable - Feed expensive and hard to obtain
OPPORTUNITIES - Build a pig value chain with better prices for farmers than the current outlets pay - Build a pig producers' association to develop specialization and collaboration - Export into DRC	THREATS - Outbreaks of African Swine Fever - Price rises for grain and not for pork

Introduction

Pig production in Rwanda is a relatively recent introduction. As in most African countries with pig production missionaries played an important role in the introduction of European pig breeds and in some instances still do (e.g. Peramiho Tanzania). There are 2 categories of pig farmers in Rwanda:

- *Small-scale village pig production*, using local breed (black, spotted), feeding on crop residues and kitchen waste. Usually people have 1 to 2 sows and either sell the piglets to others for fattening or fatten them on farm if there are enough feed resources. Animals are usually confined and sometimes scavenge when not in a pole enclosure. There is a public health risk in this production system of parasites if not kept on concrete and or dosed regularly, and a risk of infection with African Swine Fever from warthogs and forest pigs. Both risks increase when animals are allowed to scavenge.
- *Semi-intensive pig production*, using improved breeds and some commercial pig production management principles.

There is as far as consultant can see no examples of fully commercial pig production, whereby the owner/farmer is 100% dependent upon pig production for his income and in which use is made of modern pig genetics and commercial pig feed. There is one private pig slaughter facility in the country (Rulindo District) and only a handful of processors. Most pork is sold as fresh meat. In Kigali there are 3 main buyers of carcasses and sellers of pork and pork products (German Butchery, Kigali Boucherie Charcuterie and Simba Supermarket) with all three having processing facilities. The statistics show a steady increase in the number of pigs in the country, most informed people feel that these numbers are a gross underestimate of the real number of pigs in the country, as they are kept in small numbers in many households and hard to count. The southern part of the country seems to provide pork for local consumption in the region and to the informal export market to DRC; pigs from the north are locally consumed and sold into the Kigali market.

Genetics

The traditional pig breed in Rwanda is a small-sized hardy animal with low productivity but also low exigencies, which fits perfectly in an environment with a low level of resources and management capacity. Pigs are of different colours or spotted and very variable in size. It is obvious that there has been crossbreeding taking place in the past but it is hard to assess how much and where there are still pure traditional pigs.

Table 8: German Butcher

The German Butcher has been now operating for the last 14 years. He processes pigs into ham, sausages, smoked meat, does consumer packs and sells pork cuts. He processes around 100 carcasses per week, which are bought and brought to him by 5 agents. The pigs are slaughtered in Rulindo district. He does not have price differentiation and pays a flat rate of RWF 1200 per kg. If backfat is more than 2 cm he trims it off and gives it to the agent with a reduction in the weight to be paid. He never considered paying a premium for quality. He sells his produce in his own outlets, but sells also to other retailers with a wholesale margin. Source: Consultant's interview with German Butcher

Commercial pig production, like commercial poultry production, depends for its genetic resources on a small number of internationally operating breeding companies. The number of pig farmers in Rwanda who tap into this genetic resource material is extremely limited (Brother Cyrile and some government imports) and the effect of these animals on the overall genetic quality of pigs in the country is limited due to a lack of performance testing and selection, systematic exchange and transfer of breeding material. The farm of Brother Cyrile in the past has supplied many starting up pig farmers with their first gilts, so most probably the genetic basis of the pigs in the semi-commercial sector is narrow. The government has made a number of importations from Uganda and these pigs have been distributed in the various districts where people keep pigs. It seems that Belgian Landrace, Large White and Pietrain are the basis of the semi-commercial pig stock in the country. There is however no way of further monitoring what the impact of these animals is on the overall genetic composition of pigs in the country[5]. Contrary to the poultry sector, where an association has been formed, this seems to be absent in the pig production sector.

Figure 3: young breeding boars of undetermined genetics ready for sale

[5] Rushigajiki, D. and F. Nyirishema (2012): Report on field visit in northern and western provinces (MINAGRI internal document)

1.6. Small Ruminants

Table 9: SWOT Small Ruminants

STRENGTHS - Not very demanding animal in quantities of fodder required - More prolific than cattle - Local breed highly resistant to the prevailing climatic conditions and little demanding -	WEAKNESSES - Much "ad hoc" marketing when money needed, loosing potential revenue from properly prepared animals for sale - Poorly developed value chains leading to low prices for farmers - Reported high mortality in local and even higher in imported breeds - Relative long kidding/lambing intervals
OPPORTUNITIES - Start village genetic selection groups for genetic improvement of goats and sheep - Organize marketing per village/goat keepers' association - Terminal crosses for goat meat or upgrading for dairy goat breed development	THREATS - PPR coming up from Tanzania - Destruction of woody vegetation by free-range goats - Uncontrolled cross-breeding: when heterosis over it will give disappointment

Introduction

There are three main types of small ruminant production systems:

- Extensive grazing system in the East and North with predominantly local breeds of fat tail hair sheep and small East-African type goats;
- Semi-intensive system, with tethered grazing and stall feeding, using local breeds, mainly goats, in the central, eastern and southern parts;
- Pockets of introduced dairy goats with an intensive production system of stall-feeding and milking.

Goats are important animals, especially for poor families and in the areas with little grazing land. They are prolific, withstand the local conditions well and have now been adapted to the prominent system of tethering. The government has in its strategies stressed the need to increase the quantity of meat coming from small ruminants to meet the demands of the nation for meat. The choice has been to go for increased productivity per animal with the assumption that this will lead to overall increased meat production. It needs to be established however whether the imported breeds fit in the current management system and adapt to the climate sufficiently for this potentially higher productivity to be translated in higher production. There seem to be high mortality in the Boer goat flock, which could mean that the overall production does not increase if not decreases.

There were no productivity and production figures available within RAB of the small ruminants' production systems, other than that in 2010 there were estimated 2.970.780 goats and 798.836 sheep in the country (information from DVS presentation). No reliable information on kidding and lambing rate, mortality and off-take rate were found.

On goat productivity there is a Michigan state university MSc paper of Serge Rwamasirabo, giving some production data: he reports an average adult weight of indigenous goats of 25 to 30kg, first parturition at 663 days in low altitudes and 954 days in high altitudes with an average number of lambs born of 1.58.

From the crossbreeding trials with Alpine and Anglo-Nubian in the past considerably higher birth weight and weight at first service were found on station. He reports kid mortality in the first year between 20 and 30% of both indigenous and the crossbreeds and unfortunately does not differentiate between the two.

Information on the long-tailed fat-tail sheep kept in Rwanda, based on the analysis of data of the Butare research station[6], was found on the Internet.
Age at first lambing was reported as 713 days with a lambing interval of 406 days. Number of lambs born was 1.43 with a birth weight of 2.43kg. At 150 days lambs weighed 14.8kg and at 365 days 31.0 kg. The death rate to 150 days of lambs was found to be 17.5%. It is obvious that reducing the early mortality and shortening the lambing interval would increase the output per ewe per year.

In conclusion it can be said that one of the main constraints in small ruminant production is the high mortality of especially young animals. The exotic varieties need a higher level of management and nutrition, which cannot always everywhere be provided. Local goat and sheep breeds have a high tolerance against internal parasites; newly introduced breeds do not and would require regular treatment against parasites.

Genetics
Most goats are of the East African type, with at times signs of the genetic effects of earlier crossing (e.g. slightly larger and with the characteristic lines of the Alpine on the head). The sheep are of the fat-tail sheep type. There have been as in goats been earlier introductions of wool sheep (Austrian mountain and undetermined Merino's), but it is not known how large their purebred and crossbred shares in the overall flock are.

A reliable assessment of the productivity traits of existing breeds is an important benchmark against which the results of crossbreeding programmes can be checked. Various crossbreeding programmes have been conducted in Rwanda. There have been in the past importations of Anglo-Nubian, Saanen, Boer and Alpine goats and of Austrian White Mountain sheep and South African merinos, but no systematic follow up of the results was done. It is hard to assess what the contribution of these has been to the overall production and productivity of small ruminants in the country. There are currently nuclei of Boer and Galla goat on the RAB "Karama" station, where the assessment of various crossbreeds with indigenous goats is being made, and on a few private farms. Its important to identify the purpose of this crossbreeding: is it only to increase an animal's productivity in terms of slaughtered weight or is there a system perspective of changing the goat keeping system. It is clear that a heavier breed will produce more meat per animal, but on a given area of land and with a certain quantity of

[6]Wilson, R. T., Th. Murayi (1988): Production characteristics of African long-fat-tailed sheep in Rwanda (Small Ruminant Research Vol 1-1 1988), abstract: http://www.sciencedirect.com/science/article/pii/0921448888900405

fodder it becomes a different story: heavier breeds eat more and if the feed resources remain the same crossing will not contribute towards increased production within the system. If their disease resistance and further adaptability is less than the indigenous breeds then with a higher mortality rate it could be that from a system point of view these animals produce less within the given area than the local breeds. There are further initiatives of NGO's, which collect money and donate goats to poor families. It is not always clear where these goats come from. An example website is given in the footnote[7].

Besides the unanswered question of the impact of these crosses on overall production there is still the question what comes after the first cross-breeding: continuous cross breeding or the development of a new synthetic "improved" Rwandan goat and sheep breeds? And should the choice be for meat, dairy or both.

Figure 4: traditional fat tail sheep

Figure 5: Goats for sale on a village market

[7] http://www.womenofthechurchofgod.org/Store/tabid/114/txtSearch/goats/ProductID/109/Default.aspx

1.7. Cattle

Table 10: SWOT Cattle

STRENGTHS - Rwandans have a strong affinity with cattle - Government keen to develop the cattle sector and has finance - Research, Veterinary and Extension infrastructure present - Market opportunities for cattle produce in-country and in region good	WEAKNESSES - High intercooling interval and calf mortality - Limited grazing resources - Dairy value chain currently not capable to pay farmers an attractive price - No clear cross-breeding plans with farmers scared for too high % exotic genes
OPPORTUNITIES - More rational use of crop residues as cattle feed - More cultivation of animal fodder on contours and in crop rotation - City garbage incinerator at sugar factory and bagasse as basis for a complete ration cube - Start selective breeding and herd books	THREATS - TADs, especially FMD and LSD - Increasing incidence of Bovine TB and Brucellosis in dairy animals - Lawlessness leading to cattle theft - Droughts, resulting in lack of fodder - Uncontrolled crossing leading to not adapted animals

Introduction

Cattle have played, play and will continue to play an important role in the life of Rwandans. The government has played an important role in rebuilding the national herd after 1994 and is a major player in the efforts to increase the productivity of the animals present in the country. The most obvious effort is its flagship "Girinka" project, through which it has planned to assist every poor family in the country with a cow to improve family nutrition with milk, agricultural yields through manure and income from sale of milk and animals.

For the sake of analysis the cattle population in Rwanda has been divided in 4 principal cattle keeping farming systems with different developmental needs and possible future breeding objectives:

- *I) The grazing herds with Ankole animals and their crosses in the East*: the Girinka programme had as one of its purposes to destock the Eastern Province, where there was and still is overstocking due to decreasing grazing area. At the moment there seem to be various breeding strategies co-existing, whereby some farmers are crossing with dairy breeds, others with beef breeds, without a clear strategy to what point and for which purpose.
- *II) The grazing dairy herds with high-grade dairy animals in the lowlands in the Centre and the Gishwati highlands*: this segment of the national herd could be the main supplier of easy to collect milk to the formal dairy industry. Some use of AI is been made, but in most herds a bull can be seen in the herd with the cows. Holstein seems to be the predominant breed
- *III) The zero-grazed herd, largely linked to the Girinka programme:* a vast range of genetics in use from pure Ankole to imported high genetic potential Holstein animals with different rates of production and profitability for their owners.

- *IV) The purebred Inyambo/Ankole herds:* 4 herds of in total around 700-800 animals in the hands of government for the conservation of genetic diversity. This population could be increased by including particular herds with known origin in the country (see further).

Figure 8: F1 Ankole Jersey?

Figure 6: Typical Holstein (imported)

Figure 9: Inyambo

Figure 7: F1 or F2? Ankole-Holstein

The main issues of importance to be addressed besides genetic improvement are:

- There is a continuous risk of outbreaks of animal diseases such as FMD and Lumpy Skin Disease coming from neighbouring countries, requiring preparedness and rapid response when they strike. There are public health issues in bovine TB and bovine brucellosis, both also diminishing returns to farmers due to abortions and depressed production.
- Animal feeding: whereas system I seems to be fairly robust in terms of grazing and crop residues, the animals in system II in many instances lack a balanced supplementation to reach their full genetic potential for milk production. System III (zero-grazing) is short of fodder and feed in both quantitative and qualitative term. Farmers are in many instances struggling to provide sufficient fodder to their animals, balanced concentrate feed is in most cases absent or inaccessible for especially the poorer farmers concerned
- General cow management can still be improved a lot. For the sake of animal health and breeding programmes an animal identification and registration would be helpful: a start has been made with an animal identification and registration system, but it is not yet ICAR compliant and following the relevant ISO standard for animal identification.
- The formal market for milk is still pristine: the existing formal dairy processing industry has at times proven not to be as reliable and rewarding as a dairy farmer would need to make it worthwhile for him or her to invest in increased production and to stay in dairy business

- There is an (over?)-emphasize on increasing the milk production from the side of the government, not paying much attention to the production of beef from the dairy herd. A dairy herd does produce beef from its bull calves and cull cows: 67% of meat eaten in EU comes from its dairy sector.

The government policy is for people to increase their milk intake. The formal dairy industry has problems to sell its product on the local market and faces stiff competition from the many informal milk distribution networks. These results in delays in paying farmers and at times milk not collected. Although there exists export potential for dairy products into the DRC and South Sudan the companies in Rwanda lack the capacity to produce the high value dairy products, which justify the costs of transport: selling relatively cheap UHT milk with the current high transportation costs is hardly a profitable proposition.

The beef production is still largely based on grazing animals in the East and North of the country. Some individual farmers seem to have started making use of beef breed genetics (Simmental, Boran), there have been donations of semen from Botswana (Simmental, Brahman, Santa Gertrudis), but there is not as yet a national vision, policy and strategy for beef production.

1.8. Analysis and evaluation of AGI programs in place

The current programs of AGI have consisted so far of:

- Import of breeding animals for research and distribution to farmers
- Import of tested breeding bulls and semen collection and storage
- Promotion of artificial insemination with mainly Holstein Frisian semen
- Experimental use of embryo transfer

With the lack of an effective individual animal identification and registration system it is difficult to make an assessment of the impact of these interventions. The import of breeding animals has led to some nuclei on research stations, however too small to have an effective selection and improvement programme in these nuclei, so these serve to maintain the population. This will require repeat imports of at least male animals to avoid inbreeding in future.
The distributed animals (pigs, sheep, goats, rabbits, chicken) got “lost” in the overall population: with repeat crossing, sale and mortality these genetics have not been preserved as a separate entity. Although these imports must have made their impact on the overall genetic quality of the population (in either positive or negative way: hardly any systematic evaluation data beyond first crosses is known) the populations of such animals have been lost. Only when a system of identification and registration and the promotion of pure breeding with selection is set up will such populations of animals remain identifiable.

The import of tested breeding bulls requires an economic analysis in terms of cost/benefits: at the moment the country collects and freezes twice the amount of semen used per year and is faced with storage costs. In the absence of a good registration system of pedigree the risk is there that heifers will be inseminated

with semen of their fathers, considering the small number of bulls if such bulls are used too long. In genetic theory the average genetic value of test bull semen should be higher than that of breeding bulls in a country. In most countries with active genetic selection programmes it is possible to purchase such test bull semen at affordable prices, whereby a wide spread can be followed. Rwanda does not need extreme dairy cattle in terms of size, dairyness and production: it is easier to make a selection of the desired type of bulls in the enormous pool of test bull semen than when trying to procure proven bulls, which in the case of South Africa will again be based on the genetics from the countries from which Rwanda could purchase test bull semen.

Artificial insemination is a powerful tool to prevent the spread of animal diseases and to achieve genetic improvement. The effects of genetic improvement will only be seen 3-4 years after the actual insemination. In the meantime farmers have to make their money with the existing cows. The success rate of AI in Rwanda is low due to several factors. The most important one is most probably poor heat detection, difficult for farmers not used to doing this and to observe in animals kept alone in pens as many animals in the country are. Then timing of the insemination is crucial: contacting the inseminator and the inseminator arriving in time in many parts of Rwanda are not as easy as one would like it to be. In the absence of a system to check the insemination results with birth reports of calves it is difficult to make an objective assessment of the results of insemination: empirical evidence (farmers' comments, 20-25% of Girinka cows in production) give the impression that there is room for improvement. Although the government's wish to spread AI over the whole country is laudable it might be better to promote the use of young breeding bulls, progeny from AI and good bull mothers and under veterinary scrutiny, as an initial step towards cattle improvement in the remoter areas.

There are a number of techniques in animal breeding and reproduction, which have come into use in the last 20-30 years: embryo transfer, MOET[8] and genomics.
Embryo transfer makes the use of embryos from superior cows and bulls imported from elsewhere in the world possible. It is more expensive per calf born than AI and as such has nowhere become a routine way of livestock improvement. In the west it is only used to collect embryos from the absolute genetic top to implant in carefully selected and prepared carrier heifers. The actual ET is done under controlled environmental conditions, often in veterinary clinics or special sections of breeding farms. At the moment Rwanda for the moment lacks the resources and facilities for successful ET. MOET requires proven genetically superior female animals in country: in the absence of an objective performance testing system and the small population of purebred animals, in most cases without pedigree, this way of genetic improvement does not seem to be a very effective one at the moment; until there is active production recording and superior dams can be identified. It would need careful economic analysis to assess whether it is economically justifiable to apply this technique. Genomics, in which before progeny testing a first screening is made in

[8] Multiple Ovulation and Embryo Transfer, basically hormonally treating a cow to superovulate her, in vitro fertilization and consecutively implantation of the embryos after screening

the DNA for desirable genes is promising, but comes at a high cost, for the moment out of reach of the Rwandan cattle breeding system. It seems therefore that it were better to concentrate the available funds and human resources on improving the results and impact of AI and to leave ET for the incidental cases to e.g. to produce genetically promising bulls and heifers from imported embryos or collect and freeze embryos in genetic biodiversity conservation programmes.

Not all available technologies are applicable if farmers are not ready for it. In the case of AGI farmers in Rwanda still require a lot of training to handle queen bees, to manipulate hives, to control their animals to avoid uncontrolled mating, to do heat detection, performance recording etc. No crossbreeding without pure breeding: some farmers will have to maintain populations of purebred animals; animals need to be identified and registered. On top of all of this animals must have the possibility to express their genetic potential and for that they need access to sufficient quality feed, often in short supply. Only in a concerted effort in which all aspects of improved animal production are addressed will there be an effect on production of AGI.

Second part: Strategic options for genetic improvement per species

2. Genetic Improvement

2.1. BEES

Table 11: Strategies for bees

Strategic options for genetic improvement:
- Start performance testing of colonies to select superior ones - Study the 3 sub-populations before crossing or introduction foreign queens - Multiply the superior colonies in 3 regional centres and make available to other beekeepers - Train honey harvesters into beekeepers and teach techniques to produce new queens in hives

Genetic selection

There is quick and large-scale production increase to be made through changing Rwandan honey harvesters into beekeepers and adopt modern beekeeping practices (see annex 5.1). The genetic selection in Rwanda is best done as phenotypic selection of colonies with the highest production, lowest tendency to swarm and low aggressiveness. To achieve this performance testing and recording is required: this selection work can be best taken up in the demonstration and training apiaries to be developed for each of the 3 principal beekeeping areas with bees from that area. These 3 beekeeping centres, situated on or near government stations with facilities for training and lodging, are best run by capable private experienced beekeepers, who will have an additional task in multiplying the superior colonies making use of the so-called "Aalster method" (multiplication of queens from larvae in red cells in colonies without queen: an intermediate method between natural swarming and on-station queen breeding). The more advanced beekeepers with a management contract of these training apiaries will have to start performance testing of the various bee colonies: identify the hives and record production, swarming behaviour etc. From the best ones new queens will be produced, after which the old colony is split over various new colony hives. It is foreseen that each of these centres should have 250 regular hives and at any time 500 new colony hives. In this way the availability of docile well producing colonies in Langstroth hives is increased. These are then available for e.g. rural development programmes that want to promote beekeeping in suitable areas with sufficient nectar bearing plants and trees.

Reproduction

It is known that older queens produce more males than workers, so at times it is good to renew the queen of a colony for a younger one. Also when splitting large

colonies there is need for more queens. Queen breeding programmes in a station could produce such queens, but as said in the above it is hard for one centre to breed queens of the right genetic composition for a specific ecological niche as is the case in Rwanda. Import of queens is prone to risks of importing diseases (foulbrood), parasites (Varroa) or not suitable genetics (worst case scenario introduction of invading Cape bees). It is therefore important to train beekeepers in the techniques to produce queens in their own hives and take the right measures to catch the swarms, harvest the queens and replace old queens in other colonies for queens from the most productive and suitable hives. The technology to do so is there and called "Aalster method"[9], using "red-cells" to stimulate the production of young queens. These methodologies are new to Rwandan beekeepers, who deep in their hearts are still more honey harvesters than real beekeepers. There exist various manuals how to breed queens[10] on one's own apiary, making use of the best producing and least aggressive colonies.

The three central training and demonstration apiaries linked to government livestock or academic centres (suggestion NUR, Masaka Livestock Centre, ISAE in Musanze) will play an important role in colony performance testing, selection, colony multiplication, training and extension.

ACTIONS:

- **Study the various sub-populations of African Honey Bees in Rwanda and give a better description of their characteristics: determine which zones in the country use which eco/genotype of bees;**
- **Develop training material for beekeepers to learn how to select their best colonies and breed their own queen bees from these;**
- **Develop a training/demonstration centre with at least 250 hives and 500 new colony hives under contract management by an experienced true beekeeper in each of the 3 main beekeeping areas;**
- **Set up administration systems to identify hives ready for queen replacement, record production levels and other interventions with the hive and colony in these training/demonstration centres, to be copied later by beekeeping cooperative/association FFS groups.**

Organizational aspects of the sector

The sector is organized in beekeeping cooperatives, centred on HCCs. From MINAGRI's monitoring visits it is obvious that there is some confusion about the roles and functions of such organisations, which is probably a result of the quick formation and registration of such cooperatives, but too little supervision and monitoring of activities afterwards. There is need to set up a more effective support system for these cooperatives to improve on their administrative and financial management through more regular visits by extension workers,

[9] www.apimondiafoundation.org/

[10] An example can be found in http://gobeekeeping.com/getting_started_with_queen_reari.htm

support with the administration and financial auditing. They need linking up with the market through either bringing them in contact with private honey traders or assisting them to have a marketable product, meeting the standards and market requirements. Training, demonstration and extension within the sector can and should be organized in cooperative context and can be best done in the form of FFS's. RAB and the NGOs will have to develop a network of well-trained and knowledgeable master trainers with the right attitude and aptitude to facilitate the process of a FFS.

Institutional aspects

There have been various organisations active in organizing the beekeeping sector (SNV, ARDI, SERUKA, DAP). The 2007-2012 strategic plan would now need analysis and evaluation and a successor plan developed, in which the emphasis should be on further developing national apex organisations for beekeeping cooperatives, honey trade and an overall platform for improved government-private sector interaction in the sector. The role of government in terms of regulation, research and training needs to be clearly spelled out, so that both public and private sector know what to expect from one another, will not duplicate efforts or leave areas uncovered. The three envisaged main research and demonstration/training centres should be given a clear role and function within the future sector planning.

ACTIONS:

- **MINAGRI RAB and RCA agree on a system of monitoring the administrative and financial processes within the beekeeping cooperatives to encourage best practices, improve financial management and increase involvement of the members with the cooperatives. The best format would be a small task force composed of representatives of these three organisations to go around and train, monitor and facilitate;**
- **Development of a FFS beekeeping sector training and extension system to be developed, whereby cooperative's apiary or a farmer's apiary becomes the centre of the FFS: RAB's extension department to develop the methodology and take charge of the master training with experienced master trainers from the region, trained in the demonstration/training apiary of the zone.**

2.2. AQUACULTURE

Table 12: Strategies for fish

Strategic options for genetic improvement:
- Build Rwasave's capacity to deal with individual selection of superior fish ('geniteurs')
- Build capacity in hatcheries to do mass selection in parent stock and off spring
- Do provenance trials in Rwasave to assess products of genetic selection from other countries under Rwandan conditions
- Create capacity among fish farmers for performance recording to be used for genetic evaluation

Genetic selection

Especially in South Asia considerable experience in the genetic improvement of Tilapia has been gained. The so-called GIFT Tilapia (Genetically Improved Farmed Tilapia) was produced in Malaysia and transferred to various other countries. There are hybrid-breeding programmes and other upcoming lines (e.g. red Tilapia) in the world and Rwanda should keep in touch with these developments. With three different types of environment (natural lakes, ponds and cages) it is important to establish whether one type of Tilapia would be the best in all three situations and study the genetic-environmental interactions. From research in Malaysia it was found that there was little to no genotype genetic-environmental interaction for GIFT strain Tilapia between the pond and cage environments and although necessary to be confirmed for Rwanda we can preliminary assume that this is also the case in Rwanda[11]. The issue to study is whether in a system with pond fertilization the fish varieties selected under a feeding regime will be the best performers. These provenance trials and husbandry research can best be done in Rwasave Fish Research Centre, when it is run on a more commercial footing with sufficient budget, retention of revenues to be able to execute the work at hand. It should be studied whether client based paid for research could assist in solving the current budget constraints.

Genetic selection in fish is a process with different phases:

- At individual fish level with identification to do performance testing and select "geniteurs";
- Mass selection at phenotypic basis to take the biggest (fastest growth) and typical fish for breeding;
- Selection at time of hatchery multiplication.

Usually the first phase is done at a research station to produce the genetically superior animals, with which the hatcheries further select and produce the fingerlings for the commercial fish farmers. Animals in the first group are individually identified, performance tested and selectively bred to maintain the best performing families and to restrict inbreeding. Results from the GIFT programme showed an 80% improvement in growth performance in comparison with the base population in 5 generations.

---

0. 11 Hooi Ling Khawa et al (2012): Genotype by production environment interaction in the GIFT strain of Nile tilapia (*Oreochromis niloticus*) in Aquaculture http://www.sciencedirect.com/science/article/pii/S0044848611009057

In the case of Rwanda such a research centre to set up a selective breeding programme could be the Rwasave Fish Research Station of the National University of Rwanda in Butare. This station would have to develop a concise fish breeding and selection programme, supplying the 2 hatcheries for commercial fingerling production with superior reproductive material. This centre can also link up with regional and international centres to import and test the most promising genetic material under Rwandan conditions, e.g. the Ugandan Institute from where the current fish stock came. The other centres will select in the overall parent stock population and in the fingerlings to keep the fastest growing animals and reject any off-type animals. For this a breed standard has to be developed, including the husbandry system (fed or fertilized, cage or pond), at what age the animals should have what weight under a specific feeding regime etc.

Reproduction

There is currently a tremendous expansion in the number of fishponds in the country. This means that there will be an increased recurrent demand for fingerlings in future. Different types of fingerlings will be needed. It is foreseen that cage fish farmers will work with the YY-male technology (treatment of fingerlings with testosterone to turn them all male) and pond fish farmers with sexed fingerlings. The two hatcheries have so far both operated under project support and supervision and need now to be put on solid footing with private management to become sustainable reliable sources of fingerlings for fish farmers, with the capacity to deliver fingerlings in oxygenated tanks at the time when, of the right type and in the quantities required. With many of the fish ponds owned by poor rural people it is very likely that the government will have to support these farmers the first 2-3 cycles to procure the necessary fingerlings for restocking. This can be through either a direct subsidy to the hatcheries or e.g. a voucher system to the fish farmers so that they can procure themselves at reduced price and the hatcheries receive the remaining amount from government. Only with superior quality fingerlings supplied by hatcheries and fish farmers with the money and desire to purchase the fingerlings there will be a future for these necessary hatcheries and for a commercially oriented private sector driven aquaculture industry.

Institutional aspects

The government currently lacks the manpower to spearhead and monitor these developmental processes. One member of staff in RAB is responsible for the oversight of field activities and training of the extension workers, responsible to support all the new fish farming cooperatives and fish farmers with both technical and business advice. This is a sheer impossible task. Within MINAGRI there is one official, who is responsible for the regulatory aspects of fisheries and fish farming. It is foreseen when commercial fish farming leads to filleting and possibly export an enormous additional task will be upcoming to guide this process and create the necessary food safety guarantees. Therefore the creation of an aquaculture technical unit to take over the sector management tasks from PAIGELAC should be considered.

Actions:

- **Set up a scientifically sound fish selective breeding programme in the Rwasave Centre with either the National University of Rwanda or with a private entity that is capable of doing so and with the commercial interest and entrepreneurship to make this a centre of genetic excellence. This centre participates in international programmes and is linked with centres of renown to bring the best genetics, test and approve for Rwandan conditions. It provides the 2 hatcheries with parent stock.**
- **RAB, together with MINAGRI and PAIGELAC develop a database of existing and ponds to be constructed and develop a projection for the fingerlings requirements and a business plan for the supply of sufficient quality fingerlings to all the new fish farmers.**
- **Kigembe and Musanze fish hatcheries to be developed in viable sustainable privately run commercial fingerling producers to stock the existing and still under construction ponds with high quality uniform preferably sexed fingerlings, initially with some government/project support/subsidies, but eventually fully commercial with complete cost recovery and profit.**

2.3. RABBITS

Table 13: Strategies for rabbits

Strategic options for genetic improvement
- Establish a number of breeding centres with superior genetics - Train rabbit keepers in selection for certain and against other traits - Establish registration system of superior purebred rabbits

Genetic selection

Genetic selection is usually done within a pure breed, but it is unlikely that there are anywhere purebred rabbits present in Rwanda, at least the RAB and MINAGRI contacts did not know of them. This means that the selection will have to be done on-farm within the existing population and farmers will have to be taught for what to select and how. The highest heritability is for mature weight and total litter weight; fertility and vitality are two characteristics with a much lower heritability. The characteristics with high hereditability can be improved through positive selection; the characteristics with low hereditability can only be selected for by eliminating animals with poor fertility and low vitality, which is often already a normal management practise of farmers.
The variability within this mixed breeds' population of rabbits in Rwanda is high. Farmers could therefore very well set up their own breed selection scheme, whereby local adaptability can be combined with faster growth rate/higher weight. What would be needed is to introduce a system of systematic recording with e.g. breeding cards for does. Good examples of such cards are given in the APEL genetic improvement document[12].

It is important to formulate a rabbit breeding purpose, which could be:

"Through selection arrive at animals, which can give birth at least 6 times a year with an average litter size of 8, which reach an adult weight of 2.5- 3 kg in less than 3 months"

Farmers would have to identify animals through e.g. the hutch where they live and if possible tattooing, so that the superior animals can be selected. Such farmers/community breeding groups would then exchange genetic material with one another to avoid inbreeding. It is most likely that such a system of recording and information exchange within a group of farmers/FFS will promote a kind of competition between farmers to excel and improve the general production levels.

The APEL suggested and already partly executed import of commercially improved rabbits with superior fertility, mature weight and growth rate is a good mechanism to bring improved genetics into the country. To control this genetic material it is advisable to set up a limited number of breeding nuclei on existing rabbit farms of reasonable size with conditions comparable to the many farmers keeping rabbits. Their aim would be to maintain purebred animals from the imported breeding stock sell purebred bucks and does and produce F1-does

[12] Bister, J. L. (2010): Genetic improvement strategy of small stock (draft) APEL

for direct sale to farmers and to organizations interested in the distribution of genetic material. Such nuclei will have to start an identification (tattoos) and registration system to be able to select the most prolific, fastest growing rabbits. These rabbit farmers will need to be supported by the future RAB animal identification and registration centre.

ACTIONS:

- **Promote simple selection for weight and growth rate within the existing rabbit population with interested farmers: best achieved in rabbit FFS concepts and following community breeding group concepts;**
- **Develop a number of rabbitries with rabbits of superior genetics with identification, where farmers and organisations can purchase genetically superior rabbits;**
- **Establish within the future RAB animal identification and registration system a database of the above-mentioned rabbits and assist the owners of these breeding farms in the selection tasks.**

Reproduction

Reproduction in rabbits is proverbially without problems. However there are simple measures through which the rate of success of the reproductive process can be improved: keeping bucks separate from does and bring does to bucks for controlled hand-mating, record and use such records for selection against low fertility. From all the experience in the country best practices for simple nesting facilities should be collected and promoted to farmers through demonstrations and in training sessions. It seems that many farmers bring their rabbits into the houses at night to avoid them from being stolen. Handling of the pups should be avoided: possibly another form of "mobile" housing should be developed to facilitate the moving of animals into the safety of the homestead at night without upsetting the does.

Organizational aspects of the sector

The rabbit sector is very informal in all its aspects. What unites the promoters of rabbit production is that they all have a social-economic purpose for which they promote the rabbit production, not necessarily to get commercial production going. This might have clashed with MINAGRI and RAB technical staff's intentions with rabbit production, which are more geared towards maximizing the overall production, which indirectly does contribute in a positive way to the socio-economic objectives of the other actors, but forgets the extra socio-economic dimension of rabbit production. It would be good for the rabbit sector to have a number of eminent rabbit producers form their association. Such an association could then link up with its counterparts in e.g. Kenya[13] and exchange experiences, genetic material and learn from one another.

[13] http://www.globetree.org/africa/rabbit-net/<http://www.globetree.org/africa/rabbit-net/>

Schools' role in the promotion, training and demonstration of good rabbit husbandry should be strengthened: many adults can learn through their children. Youth rabbit clubs in schools can be formed to promote the actual selective breeding principles, based on performance testing and recording, which analysis could become part of the school activities in the field of maths and economics. An informal rabbit producers' and promoters' network would help in sharing experiences, both the positive and negative ones, in rabbit production. Such a network could keep through a dedicated website people informed about the availability of breeding material, new experiences, training and extension sessions.

Institutional aspects

The Ministry and RAB have each one officer responsible for rabbit production. It is obvious that their influence on what is happening in the rabbit sector is necessarily limited to making sure that the set out policies and strategies are followed and that the quality of training and extension is assured. There is need of sufficient up to date knowledge on modern rabbit keeping within the Ministry. If this is not available then someone should receive training and become the TOT for others, both at Ministerial as at field level. A simple strategic plan for the development of the rabbit production sector in the country produced and agreed upon during a stakeholders'meeting with the most prominent representatives from larger-scale rabbit farmers, representatives of Educational Institutes, fish farming bodies and NGO's promoting rabbit production, would be a good way to create broad consensus on how this important sector for poverty reduction and achieving family food security can be further developed.

2.4. POULTRY

Genetic selection

In the *village poultry sector* there is a large genetic variability due to the past distribution programmes of all sorts of poultry genetics. This variability provides the opportunity for farmers to select their type of chicken with superior adaptability to the local conditions and suitable for the type of production they contemplate, which will usually be a combination of eggs and meat. A deepened understanding and insight in the current production level of the village poultry sector and its variability will make it possible to decide how this sector can be supported in genetic selection or e.g. the introduction of cocks of other breeds for cross-breeding. The breeding purpose for village chicken could be:

Table 14: Strategies for poultry

Strategic options for genetic improvement
- Study village chickens' performance and identify superior sub-populations - Train farmers on village based selection in existing poultry for certain traits - Establish parent stock farms with suitable breeds for improvement of semi-commercial poultry keepers - Improve quality control of imported commercial chickens

"A robust chicken with an adult weight of at least 1.5kg for hens and over 2.00 kg for cocks after 6 months, well adapted to both free range and confinement, laying at least 100 eggs a year under the basket chick rearing system in 5 clutches and with good brooding characteristics."

The *semi-commercial poultry sector* can make use of both commercial and local breed birds. It is the economics of the production, which determines what breed farmers will use. The mini-hatcheries could produce F1 commercial layer-local cock chicks, vaccinate and rear these for sale as rustic crossbreds to the village poultry sector or institutional buyers purchasing chickens for this sector. It could not be established whether in Rwanda there are flocks of the traditional poultry breeds (Rhode Island Red, Plymouth Rock, Leghorn etc.). Such breeds could be maintained in this sector for both pure-breeding and crossbreeding purposes. So also with the "Kuroiler" if the current tests turn out positive. It would require more study to find whether such breeds are still present in Rwanda, if so what their genetic and commercial potential is. This semi-commercial poultry sector with small-scale incubators and hatcheries can play an important role in making suitable slightly more productive chickens available, when the availability of feed and veterinary care improves, to the village poultry sector. A breeding purpose could be:

" Hens of at least 1.5kg adult live weight and cocks of at least 2.0 kg adult live weight, with an egg production per hen of at least 175 eggs per year, with only occasional birds going broody. Birds should be able to be kept through moulting and used for a second cycle, producing at least 150 eggs. These productions are reached with simple rations, based on local grain, scavenging and some concentrate feed".

The *commercial poultry sector* has no need for a genetic improvement strategy: the only task for commercial poultry producers is to match the environment they

can provide for the chickens with the requirements under which these birds can express their genetic potential and under which they have been selected. This means all stable climate; feed, health care and general management practices will have to match the stipulated requirements of the various breeds. Genetic selection is the exclusive task of the poultry genetics companies dealing with these breeds/brands of chicken. This applies to both layers and broilers.

Reproduction

As earlier said the *village poultry sector* can improve the efficiency of its poultry's reproduction tremendously with the earlier referred to basket brooding method, early separation of chicks from the hen, who will start laying again quicker under such conditions and increased vaccination of chicks and hens against NDV.

The *semi-commercial poultry sector* should be linked to the mini-hatcheries, which concentrates on producing types of rustic chicken for this sector. This can be F1s of commercial varieties, which will genetically still be able to lay 250-280 eggs per year, crosses between commercial varieties and layer breeds or local chickens as parent stock with cocks from commercial layers/'Kuroiler' etc. Research will have to work hard together with the village poultry farmers and the semi-commercial poultry sector to determine which type of bird is the most suitable under village conditions to be multiplied.

The *commercial poultry production sector* will have to make its plan to what extent it is profitable to build up local chick production through import of parent stock, running incubators, following a comprehensive vaccination schedule and rearing these chicks up to POL in case of layers. Experiences with certain imported batches have been bad with CRD coming with the chicks and eating the profit of that batch, leaving the farmers with a loss. It would be a government task to assess the capability and value of certificates of the various veterinary services of the countries from which chicks are being imported. It would need detailed economic analyses to determine which strategy would be the best for the moment and when and how the country could change from one strategy to another. The technical results of e.g. the Rubirizi parent stock farm and incubator do not match with what is internationally accepted as minimum standard. Again, these aspects will be dealt with in the study for the development of Rwanda's commercial poultry production sector.

Actions:

- **Develop a far better understanding of the current production levels and practices in both the village and semi-commercial poultry sector, with the use of NGOs and extension workers: only through this the bottlenecks in the production system can be properly spelled out and addressed and the most suitable genetics selected.**
- **Link the existing mini=hatcheries with the semi-commercial producers and decide together on what type of chicken is the most suitable for that sector and produce that one in bigger numbers, making sure that chicks are properly vaccinated.**
- **Commercial poultry sector stakeholders together with government responsible bodies develop a strategic plan for the development of the commercial poultry sector in Rwanda (see also poultry sector consultancy report).**

Organizational aspects of the poultry sector

There is a Rwandan Poultry Producers' Association with a number of active members, representing mainly the commercial poultry producers. This association has now started to be involved in the development of a commercial poultry sector development plan. The poultry value chain needs a chain manager and this association, if there will come representatives of feed industry and grain trading and the import, distribution and sale of veterinary vaccines and drugs, might just be the right organization to take on this role. There would be need for value chain development business support services to strengthen the capacity of this association to take charge of the developmental aspects of the sector. This will most probably mean that an integrated poultry sector development project with foreign TA during 3-5 years would have to drive the process.

There are probably various farmers' associations/cooperatives, often women, who are engaged in poultry rearing in their villages. These need to get into touch with potential concentrate and chick producers, from which they can purchase their replacements chicks/chicken and concentrate. There is need to incorporate such associations within the overall value chain. Here lies a future task for the Rwandan Poultry producers' Association.

Institutional aspects

MINAGRI and RAB have 1 officer each at national level responsible for poultry production. With RAB now dealing with extension, research and the government interventions in the sector it means that these 2 persons cover the whole range of legislation, regulation, training and extension, demonstration and monitoring and evaluation. Too many tasks to be involved in all of them, but definitely with the need to remain informed on all public and private sector interventions and actions within the sector. Together with the director of Rubirizi and representatives of the Rwandan Poultry Producers Association these people could together form the National Poultry Development Board, which would have as its key role to do whatever it needs to improve the functioning of the poultry value chains, to defend the interests of the poultry value chain stakeholders and promote the various businesses involved in the poultry sector.

ACTIONS:

- **Develop a sector-wide poultry development platform (national poultry production board?), where the various stakeholder representatives meet, develop strategies, exchange experience and together with government decide which interventions would be the best for the sector.**
- **Strengthen value chain management and appoint a poultry specialist to drive the process of the development of the commercial poultry sector together with the stakeholders, to build their capacity and to link Rwandan commercial poultry farmers with the international practices and knowledge.**
- **Develop far better economic and financial intelligence on the poultry sector, at national, regional and international level.**

2.5. PIGS

General

In a modern vertically integrated pig production column the following steps can be distinguished:

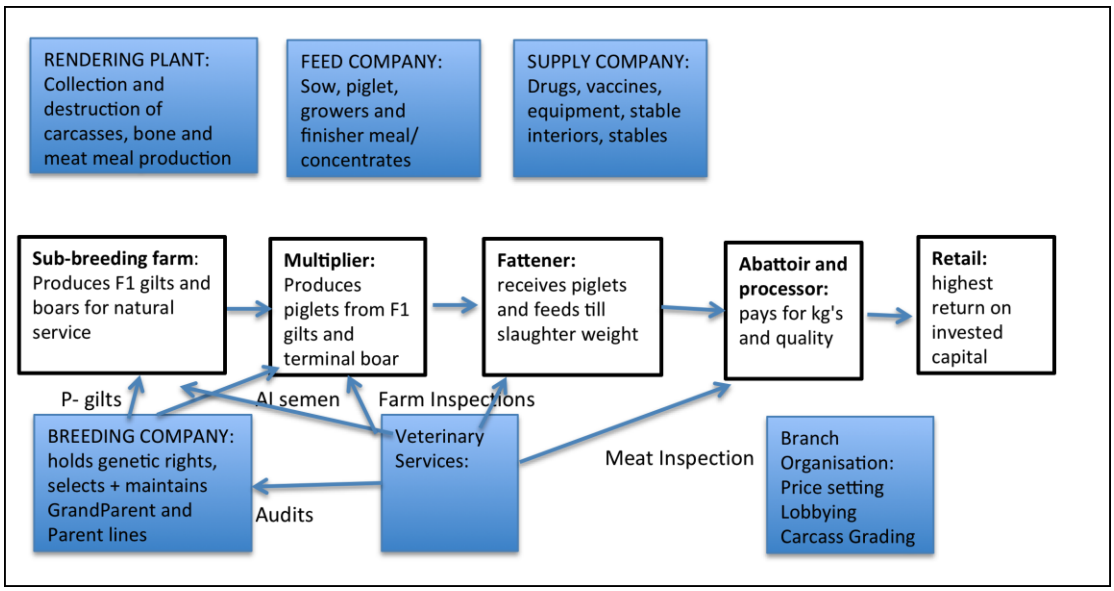

Figure 10: a schematic overview of pig production value chain

The Rwanda pig production sector operates under a much simpler operational scheme: in most cases all these functions are concentrated on the one farm.

Specialized farms:

Every pig farm in Rwanda is into breeding, multiplying and fattening animals. There is no specialization. One cannot be a master in every step and specialization should at some stage occur. To achieve this there is need for the development of the pig/pork value chain, the organization within the sector, developing a contracting system so that some farmers can specialize on the production of terminal boars and F1 or Landrace or Large white gilts, with which others produce piglets. Although it is quite common in the family sector for people to sell piglets it is likely that splitting the multiplication and the fattening would take more time from splitting the breeding and multiplication/fattening. The contracts used between the various stakeholders need to have minimum standards prescribed, price calculation mechanisms, based on the price of feed, genetics and the slaughter price and arbitration mechanisms.

ACTIONS:

- **Get a number of pig farmers together (see inventory!) and discuss the setting up of a number of collaborating farms with different functionalities (see under genetics)**
- **Discuss with one another pricing mechanisms for breeding material and weaned piglets and a price setting mechanism for slaughter pigs based on weight and quality as an incentive for improvement**
- **Set up the farms with imported genetics and a boar station either on farm or centrally (see further)**
-

Breeding

Table 15: Strategies for pigs

Strategic options for genetic improvement
- Establish pig AI with semen from superior commercial boar lines - Organize the sector into specializations: gilt production based on high fertility and mothering capacity, terminal boar production based on growth and meat/carcass quality

Genetic selection

In modern pig production use is made of commercial lines, maintained and continuously improved by commercial breeding companies. In this case the only thing left for the pig farmer is to create the environment, under which this genetic material can reach its full potential and select in his gilts before they are inseminated. As with hybrid maize, which gives disappointing yields when not accompanied with the right amount of fertilizer, so will pigs of this modern genetic composition not perform if the environment is not right. This means that Rwandan pig farmers in principle are left with the selection of gilts from their existing sows, whereby fertility, vitality, back fat, growth rate and phenotype are the main selection criteria.

In commercial pig production use is made of a sow line and a terminal boar line to produce the slaughter pigs. The sow line is often itself a product of a cross between two lines, the terminal boar line is usually a selection of a slaughter type large-white. The following figure gives an impression how nowadays slaughter pigs are being produced:

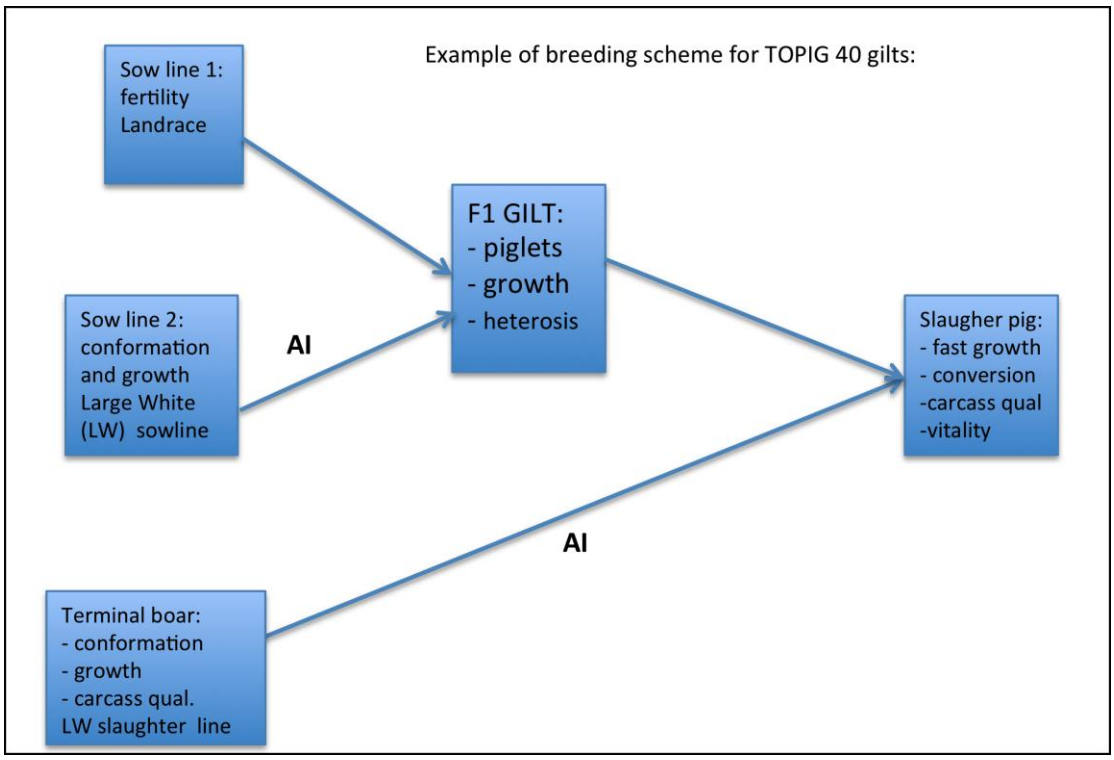

Figure 11: crossing scheme for production of slaughter pigs

These pig genetics companies are at the moment not represented or present in the Rwandan market, but Rwanda will need to gain access to these internationally achieved selection results. The nearest representatives of such organisations are in South Africa (with SPF farms) (Topigs: www.topigs.com) and Kenya (Hypor: http://www.thepigsite.com). This linking up and incorporating this genetics in the chain would require structure and

collaboration within the pig production sector, currently absent, but possible to be created as described above.
The most important action for genetic and performance improvement would be to establish the production of either purebred Large-white or F1-sowline gilts with superior fertility, mothering capacity and conformation to the currently used pigs, which seem to be performing in terms of weaned piglets/sow per year and growth rate at 50% of what is standard in the West (not all caused by genetic factors!).
The breeding purpose for such sows should be
"Sows with the capacity to farrow at least 2X per year with average 12 piglets per farrowing, of which 11 are weaned. She should have longevity and vitality to last at least 8 farrowings, growth rate herself of more than 500gr/day and backfat less than 15 mm. "

A quick way to achieve this without long selection within and improvement of the existing pig population to get such sows would be the import of a nucleus of superior gilts to produce this improved genetics in-country. Earlier experience with government structures has been disappointing and the best option would be for a private individual or a group of private pig farmers to further develop such an imitative of forming a breeding nucleus.

Semen of terminal boars could become available in two ways:

- Imported from e.g. South Africa: fresh semen in climatized box does keep its quality for 4 days; with the number of flights per week to Jo'burg it is possible to have regular supply twice a week. Cost would be cost of semen and transport, which would for a batch of 150 doses, be around USD 3000 total.
- An association of pig producers or an individual pig producer could establish a small boar station with imported boars of both sow and terminal slaughter lines. This would have to be costed and studied in terms of logistics, capacity and financial requirements (see annex 6 for an estimate of running cost).

There is need to set up a register of these genetically superior animals at country level. Animals will have to be tattooed and/or tagged and entered into a database. Existing registration systems can hopefully be amalgamated with this envisaged register and so converted into a national pig breeding/pedigree registration system.

Reproduction

For the indigenous pigs no other interventions are foreseen other than probably crossing with European breeds for those farmers with sufficient available feed resources, who want to bring their pig husbandry activities at a higher level. In communities with a high density of indigenous pigs and sufficient availability of feed resources it could be considered by government to make F1 boars from the F1 gilt production available to increase size, fertility and growth rate. However: it would require first careful study to better understand the demands of the market for these traditional pigs- it is well possible that this market does not desire larger size carcasses.

For the commercial pig sector the reproduction can be done in two ways:

- *Farmers keep a terminal cross boar* to cover their multiplication gilts. Such boars are produced on the earlier mentioned breeding farm and sold to interested farmers. This is probably the best way, especially for farmers far away from Kigali or in remote areas
- *Farmers use AI with either imported or locally produced semen:* this will require a pig AI structure, either linked to government, but probably preferably operated by private sector/ the pig producers organization.

It is important to make pig farmers aware of the different lines existing to produce sows and slaughter pigs and to start the process of bringing structure into the use of genetic resources/different lines in the country.

ACTIONS:

- **Establish contact with pig genetics company/ies, which are interested to work together with Rwanda;**
- **Develop within the pig sector master plan a genetic improvement chapter, together with the above mentioned company/ies and core pig farmers and make the critical choices (import semen, own boar station for semen collection, breeding and selecting own gilts, establishing a nucleus with imported gilts and boars/semen);**
- **Develop a business plan for the commercial linkages needed to provide terminal boar and sow-line semen and AI services to the pig producers, probably initially geared towards pig farmers around Kigali and Gicumbi (historical pig production areas).**

Organizational aspects of the sector

Institutional aspects

Currently the institutional responsibility for the sector is vested in 2 persons: one from MINAGRI and one from RAB. This is not sufficient if this sector, without any strategic plan or active outside support, has to be modernized. There is need for an overall Pig Sector Development Master plan, best developed within the context of a separate developmental project, in collaboration with MINAGRI and RAB and sector representatives.

ACTIONS:

- **The sector should work towards setting up a lean and mean pig industry board, which in future takes charge of managing the pig value chain in the country so that there will be a market for breeding stock of excellent genetic quality, AI available and a pig genetics registration system.**
- **The sector, together with government should develop a master plan for the pig sector.**
- **A donor/project would be critically important to initiate, monitor and drive this process.**

Extension, training and research

Very little is known about pig production in Rwanda, especially in the small-scale production sector. There is need for on-farm research into the production and productivity of the traditional pig farming systems. There seems to be currently

a large number of people who are trying their luck in pig production, as it does not require land. It seems that these have little to no access to examples of suitable pigsties or simple manuals on pig production and too many beginners' mistakes are made. Also the extension services are not experienced in pig production and their knowledge has to be built up and/or refreshed. This could best be done in some strategically positioned demonstration piggeries, linked to the livestock research centres in the country (see further).

2.6. SMALL RUMINANTS

Table 16: Strategies for small ruminants

Strategic options for genetic improvement
- Break the negative selection through establishment of community breeding groups - Establish a productivity and production monitoring system in a sample of the village flocks - Establish breed standards and flock books for the various pure sub-populations in the country - Establish an identification, registration and performance testing system for purebred animals

Genetic selection

Due to the various uncontrolled cross-breeding programmes from the past and the already naturally occurring high variability within the goat and sheep population for most traits it is very well possible to make quick genetic progress if a simple community based mass selection and breeding system for both goats and sheep is set up[14]. Currently in most instances there is negative selection for growth rate, carcass quality and fertility/precocity in the community's sheep and goat flock due to the fact that the fastest growing lambs and kids are sold the first and the laggers remain behind and will form the replacement stock or even become the breeding billy or ram. Instead of the introduction of exotic breeds, which give in the first 1 to 2 generations excellent results for large part caused by heterosis lost later on together with adaptability of the animals to the climatic and disease conditions, it is better to set up such a community breeding and selection scheme, which gives better chances for sustainable genetic progress at a far cheaper price than crossing with imported breeds. The whole concept can be best developed in a Farmer Field School (FFS) concept, which will cover the overall management system for sheep and goat keeping.

In both goat and sheep breeding the breeding objective for meat production should be:

"To produce the maximum kgs of kid or lamb meat per doe/ewe per year"

In this way one has an aggregate breeding purpose that selects for kidding/lambing interval, number of offspring/lambing/kidding, growth rate and makes maximum use of the available fodder and feed reserves. Selection for productivity per animal in conditions of limited fodder and feed reserves is most probably not the wisest thing to do. Farmers will have to be taught to record the events in their goat and sheep flock, whereby schools and school children can play a role. Extension workers can assist the groups with the analysis of data.

For the goats that are being milked (descendants of Saanen/Alpine) and where the farmers really want to select within the cross-breeds for the best milkers a simple system of production recording with once monthly recording of all goats'

[14] http://www.icarda.org/docrep/Training_Manuals/Guidelines/Guidelines_for_sheep_breeding.pdf

production in the morning and evening should be done. From this, together with a breed standard in case the farmers opt to go for a particular phenotype, billy mothers and billies can be selected that best correspond with the breed standard from proven good producers.

Meanwhile the current on-station and off-station with Boer and Gala goats should be analysed to assess their productivity in terms of kg meat produced/kg doe/ewe per year. The current Boer goat import seems to be the third (once before 1994, NUR in 2003) and it is not clear what the beneficial effect of these imports has been. RAB will have to maintain purebred populations of Boer and Gala in case farmers are interested in crossbreeding their animals with these breeds after it is proven that this is beneficial. It should then however also be determined what will be the next step after the F1: a terminal cross with slaughtering all offspring, backcrossing or criss-crossing?

The imported "merinos" under the APEL project, being kept at ISAE in Musanze, are supposed to be for both lamb/mutton production and for wool. It will have to be analysed carefully whether these sheep show sufficient adaptability to the high altitude far more humid conditions than where they came from in Uganda. Especially in terms of parasite resistance the African fat-tail sheep have shown a tremendous capacity to withstand high infection pressure without frequent dosing. Only a genetic comparison in terms of lambing, weight and lamb production is not sufficient to come to a valid conclusion, especially if the observations are done on station. In a farming system analysis, whereby farming indigenous sheep and these exotics are compared in quantitative and financial terms can one determine with which breed farmers can make most money.

Reproduction

Two categories of animals can be distinguished:

- The freely grazing ones;
- The tethered and zero-grazed ones.

In the first group, when there is a village flock or flocks grazing in the mountains near to one another sheep and goat farmers will have to reach an agreement on what type of billies and rams will be used. When the FFS style community breeding groups have been formed and the superior young breeding billies and rams have been identified farmers will have to make sure that other billies and rams are sold before they become sexually active, castrated or "equipped" with a sheath to prevent breeding.

The described breeds (Boer, Gala, Saanen, Alpine, "Merino"), which are kept in pure form should only be exposed to controlled breeding. With simple doe/ewe cards the performance should be recorded so that a start-up of a national register/flock book for these breeds can be established. Only in this way will it be possible to do genetic selection in these populations of animals. It seems that at the moment only RAB's Livestock Experimental Stations in the country can be considered capable of developing such a programme, including the individual animal identification (the 2 Karama and Songa stations).

ACTIONS:

- **Establish Farmer Field School goat and sheep production groups that will partner up with research to better understand existing production systems;**
- **A monitoring system of a random sample of village goat and sheep flocks to establish better insight in the productive parameters of the indigenous breeds;**
- **Set up community breeding groups linked to the FFS's to start community goat and sheep selection and breeding.**
- **Develop a breed standard and initiate flock books for the existing Boer, Saanen, Galla and Alpine animals in the country with a related selection and breeding programmes to improve on the breeds.**

Organizational aspects of the sector

There does not seem to be an organization of goat and sheep breeders. An inventory should be made of potentially registered goat and sheep keepers' associations/cooperatives with the Rwanda Cooperative Agency and studied how the FFS and breeding group concepts can be brought in line with a joint effort of livestock keepers to jointly improve their business through joint selective breeding, purchase of inputs and veterinary services and organize their marketing together.

The breeders of particular breeds such as the Saanen breeders in Eastern Province, the Alpine goat breeders in Western Province, could be encouraged to form breed societies as precursors for later flock book organisations, pedigree recording and breeding. The NGOs that brought in these animals can play a role in assisting farmers to organize themselves for this pedigree work, if they haven't done so already.

Goats play an important role in many of the rural development and rural poverty eradication programmes in the country. It was good if these projects/organisations form together a NGO livestock development platform for the exchange of experiences and try to create synergy in their actions. It will contribute towards more sustainable interventions in the goat and sheep and other livestock sectors.

Institutional aspects

Within both MINAGRI and RAB there are people responsible for the small ruminants. These will have to develop a joint strategy, together with representatives of research, extension, the above mentioned goat and sheep NGO platform and the larger commercial goat and sheep breeders to come up with a widely carried plan for the development of the goat and sheep industry in the country. At the moment the various efforts to do so are disconnected and could benefit from a more coordinated approach. It is suggested that the person from MINAGRI being responsible for policy, strategy and regulation takes the initiative to get such a process going.

ACTIONS:

- **Identify from the Rwanda Cooperative Agency all the goat and sheep production cooperatives, which could be encouraged to form community-breeding schemes.**

- **Develop Farmer Field School concept of extension and set up Community Breeding principles with the members.**
- **Create a national small-ruminant production platform with representatives of all sectors involved and develop a master plan for the development of goat and sheep production, in which research, breeding, extension and further financial support to farmers is defined. Meet regularly to report on the progress on the implementation of the goat and sheep production master plan, to fine-tune and to create synergy and collaboration**

Figure 12: imported wool sheep: Merino?

2.7. CATTLE

Genetic selection

For meaningful genetic selection it is good to determine what the breeding purpose of farmers is. It is well possible that the various cattle production systems have different breeding purposes:

Table 17: Strategies for cattle

Strategic options for genetic improvement
- For dairy production start with F1 Holstein-Ankole (cross) and then follow criss=cross Zebu type (Boran/Sahiwal) * Taurine type (Holstein/Jersey) - Establish herd books for >75% pure Holsteins, select bull mothers, inseminate with import semen - Reconsider to change import of proven breeding bulls for import mix of test bull semen from proven bulls - Beef production start with local cross and criss-cross Taurine (Limousin/Simmental * Zebu Boran/Sahiwal): F1's heifers of Boran/Sahiwal cross for Girinka (avoid Brahman as hard to handle)

I) Grazing herds with Ankole and their crosses in the east of the country: in discussions with these livestock keepers it is obvious many farmers are not interested to go beyond 75% exotic genes in his cattle due to increased disease risk. If some farmers would still want to aim for 100% pure exotic they should be cautioned, considering the disease and adaptation problems. If the production purpose were pure milk Jersey would be a suitable breed to cross with. But beef is also important and the Jersey bull calves produce less beef than the Holstein crosses. These farmers could practice a criss-cross breeding scheme between Holstein and Sahiwal/Boran. This crisscross is reasonably fool proof: if the animal has a hump get the Holstein bull, if it does not have a hump use the Boran/Sahiwal bull. It is relatively easy for the country to buy a few Boran bulls or import embryos from Kenya and use them on the Masaka bull station for semen collection; it seems more complicated to obtain Sahiwal semen as the Naivasha national Sahiwal stud seems to be on its last legs; import from India carries the risk of introduction of diseases and there is a widely heard complaint about the temperament of the Sahiwal. In this way the genetic composition of the animals will never be more than 66.25% exotic genes and always a minimum of 33.75% zebu blood. The resulting animals after a few generations if proving suitable can be developed into a synthetic breed by using cross-bred bulls, but for the time being that is not relevant as yet. In this way farmers will have a cow that gives and milk and is suitable for beef production. It has reserves to fall back on during droughts, which the Holstein does not.

Another production purpose for selection farmers could be heifer production. Currently the government buys the heifers required for Girinka through open tender. It were better to give farmers a service contract to produce F1 Ankole/Holstein heifers through the use of sexed semen. Ankole cows and heifers would be synchronized and inseminated with sexed semen so that 90% of the calves born will be heifer calves. These heifer calves after reaching approximately 300kg could be inseminated with Boran or Sahiwal and go as pregnant F1 heifers to the beneficiaries.

All in all the breeding purpose for the cows in this sector could be:

"Cows capable of calving once years, even under adverse conditions, produce besides the milk the calf consume 2000liter/year on minimal supplementation. It should be minimum 400kg adult weight at 3 years and be with average musculature and suitable for both milk and beef production."

It should be noted that no specific reference is been made to a breed and/or colour- these farmers will develop a multiple purpose cow breed that serves many purpose: milk, F1 heifer and beef production.

II) The grazing herds with grade dairy animals of the Central zone and the north have different opportunities: the central zone farmers can relatively easily sell their milk to the dairy and demand a higher price because of quantity and distance and hopefully in the future because of quality. This option is absent for the Gishwati farmers. During the mission farms near the dairy plant were receiving up to RWF 200/litre, whereas in Gishwati the price was between RWF 100-110. The central zone dairy farmers can afford to continue on the Holstein pathway and should start their Holstein register, culminating in a herd book in the long run when 3 generations parentage have all been registered. These herds should be inseminated with good semen of a wide variety of Holstein and if wished Jersey bulls so as to make compensatory mating to aim at the ideal Holstein/Jersey cross type for both exterior and milk production. The breeding purpose could be:

" Aiming at well-developed cows of more than 450kg adult weight, capable of producing 4000 litter in first lactation and over 5000 in further lactations, calving once a year on a ration of grazing with modest supplementation".

These herds should be inseminated with a "bouquet" of test bull semen from European Holstein breeding countries (and USA, Canada), being cheap and in theory the best genetics to be had. Animals should pass a simple performance testing scheme and the best milkers in each herd to be compared with the best milkers in other herds, corrected for herd averages, to determine the future bull mothers, to be inseminated with imported semen and producing future breeding bulls for use in the MCCs where AI is not successful or an inseminator absent.

The Gishwati farmers can depend less on milk than their brothers near the dairy plant and would want to keep some suitability in their animals for beef production. As the old breed in the area was based on Ankole/Jersey/Sahiwal it won't be foreign for these farmers to practice a criss-cross between Holstein/Jersey and Sahiwal/Boran as desired. The cross will phenotypically show who the father line is through the presence or absence of a hump. In this way the level of European exotic blood does not get higher than 66.25% and the animals will have aptitude for both beef and milk production, producing cows with a good rest value and bull calves with potential for beef production, either through grazing or through feedlotting.

III the zero-grazed animals are all crosses and as such not interesting to be included in genetic selection programmes other than selecting the dams from which to keep heifer calves, but that is very much a farmer managed activity. Aiming at a short generation interval, making use of HF test bulls there is no need to do performance testing of these bulls' progeny: every year other semen will be used. As farmers have a crossbred Ankole* Holstein (or Jersey if clients ask for this) cow, which produces a (Ankole*HF)*Boran

or Sahiwal calf he/she has to decide whether to keep a 3 way cross heifer calf. It were better to encourage such farmers to sell any offspring and cull cows to fatteners in the Eastern Province and buy a replacement F1 heifer. In this way the pressure on feed resources in the highly populated areas can be controlled.

IV there are two indigenous cattle breeds: Inyambo and Ankole. It is said that the Ankole is a stabilized spontaneous cross between the "Inkuku", a small East African zebu type animal and the taurine Inyambo. This would mean that the Ankole is a Sanga type with a slight hump and the Inyambo should not show a hump. It is not clear how distinct these two breeds are and whether they should be, but that is to be decided by the principal breeders, which seem to be among others the presidents of the various countries. Purebred Inyambo and Ankole should be identified with a chip so as not to destroy the attractiveness of the animal with ear tags and make a more secure marking. There should be developed a stringent breed purpose for the Inyambo which reflects both the outer as the production traits:

> "The Inyambo is a beef breed of dark red colour and large white horns, which grow sideways and point backwards. Any misshapes of horns will pose a disqualification from the Inyambo register. The adult cows should measure at least 1.30m at the shoulders at maturity (bulls 1.40m) and weigh at least 350kg (bulls 450kg). Cows should without supplementation on natural range be able to produce 1 calf per year. "

Only when setting a breeding purpose can a selection programme be started up. The role of the Inyambo should be to provide heifer F1 breeders with suitable bulls to maintain their Ankole/Inyambo line of animals.

The pristine Rwandan pure beef-breeding sector is not described as yet, but seems to be farmers experimenting with Simmental and Boran. Although the Simmental is a good beef breed it might be that in Theileria country the Boran with better tick resistance would be the more advisable choice for beef production. Although the MINAGRI policies stipulate that meat production will come from small ruminants, pigs and rabbits it should not be forgotten that there is no dairy production without beef production from bull calves and cast cows. It should also be accepted that certain areas of the country due to their remoteness and fodder availability are more suitable for beef production.

Reproduction

Rwanda is heavily promoting the use of AI, but the results are reported quite differently by the various stakeholders: inseminators claim 65-80% success rate, the Masaka bull station reports 40-50% success, farmers are more conservative and hold it at 20-30%. There are a large number of factors that determine the success rate of artificial insemination:

- Proper heat detection by the farmer, extremely difficult in cases of 1 cow in a pen or animals in the pasture and not collected twice a day.
- Proper experience of the inseminator: most of the inseminators in Rwanda are not as yet doing sufficient inseminations to build and maintain their skill level.

- Proper recording of births of calves, including information on ease or difficulty of calving: only through this the quality of AI and suitability of a bull in terms of calving ease can be assessed and would thus need an identification and registration system of cows, central registration of inseminations and a birth reporting system.

AI results can be improved by excluding the far away areas where the inseminators might have a problem to reach the cow within 12 hours after the set-in of oestrus. Insemination in faraway places by a sector veterinarian are expensive because of the travel costs and in case of negative results expensive for the farmer due to lost money paid and lost 3 weeks of milk (i.e. if he did keep the cow properly isolated to prevent natural mating). The almost routine use of hormones before insemination should be discontinued as too expensive, possibly facilitating the breeding of reduced fertility animals that should not be re-bred and not healthy for the cow.
Another positive effect on AI results would be to locate the AI at the MCC, whereby the veterinarian working there becomes responsible for the health care of the animals (contract with government in case of a private vet), individual treatment (payment by farmers), tagging and registration and insemination (paid for by the MCC from their overheads). The district vet remains responsible for supervision of the work of the MCC vet. The MCC veterinarian becomes a multiple-purpose person living within the community, who is also responsible for extension messages and becoming the master trainer for FFSs staring up in that MCC.

Currently Rwanda is collecting its own semen from 13 bulls at the rate of 120.000 doses per year against a use of 60.000. The purchased bulls' daughters would around 2.5 years after the bulls were purchased require different bulls' semen to avoid inbreeding. At that moment in theory there should be already a double amount of the annual offtake of a bull's semen be present, so he could be slaughtered then. Currently it is doubtful whether there is a workable recording system, which without an Identification and Registration system guarantees that heifers are not inseminated with semen from their own fathers. In that situation it is better to not collect and freeze semen but buy from organisations of renowned test bull semen and use this. In this way the semen list can be changed every year, the cost of buying and keeping bulls, collection and processing and storage of semen reduced. Rwanda would make use of the best genetics from countries with active performance testing programmes as the basis for their genetic selection of bulls. It could also opt for easy calving bulls and sexed semen for those who want a bigger likelihood of a heifer-calf.

Embryo Transfer (ET) is only paying in case of extremely high-level genetic material or as a means to transport animals from one country to another, when there are risks of diseases in live animals, which can be excluded when sold as embryos. Rwanda gained its experience with British embryos, through which e.g. future test bulls could be imported from overseas. ET however requires so much veterinary supervision, hormones in carefully prepared heifers and without large numbers of ETs the technical results are not good. It is at the moment in terms of cost-benefit not opportune for Rwanda to further engage in commercial ET, but should be limited to e.g. collecting embryo's from superior Inyambo cows for genetic conservation, strengthening future pedigree breeding through the

import of carefully selected purebred embryos of Jersey, Holstein Friesian, Sahiwal and Boran, but not as a routine reproductive technique.

Organizational aspects of the sector

In the livestock improvement the MCCs and cattle cooperatives will play a key role in general service provision to livestock keepers, registration of animals and animal movement, training of farmers and liaison with government and support programmes. In the long run it could be that the sector veterinarians will be attached to farmers' cooperatives/associations and work as their employees with a PPP contract to execute government mandatory tasks for public health, veterinary health and general public management roles (e.g. statistics).
With an identification and registration (I&R) system of animals in place a start can be made to open registers for the various breeds of animals, resulting eventually in herd books for the various breeds to be kept pure. This is a private domain activity, in which the government services, as they already maintain the cattle Identification and Registration system, could provide services. The government in this way facilitates and supervises. An I&R system should be based on double tagging (left and right ear) according to ICAR/ISO standards, whereby the MCC could be the holding for the smallholders. Starting with the cows inseminated and recording the breed of the bulls used with a good birth reporting and registration system an animal's genetic composition can be better recorded than is now the case. With a criss-cross breeding scheme in cattle the animals phenotype (hump-no hump) will assist in identification of the genetic composition.

The MCCs seem to be "produced" by the Rwanda Cooperative Agency. These MCCs have to start to consider themself as the body for general improvement of cattle husbandry; breeding and marketing of milk and as such play a key-role in the cattle development. The Ministry should acknowledge that role and work together to improve the functioning of the MCCs through a training and supervision programme, which tackles both the financial/administrative roles of the MCCs but also the technical aspects of their service provision.

The recently formed dairy development platform should be the place where the various stakeholders within the dairy sector meet and take decisions for the sector. This is the place where public and private parties meet one another.

It were good if the various MCCs and other interest groups form their own cattle producers' association (on purpose formulated like this: if it were only for milk the interest might wane in the periods that it is not profitable to produce milk for the formal market.

Institutional aspects

There are a number of government institutions involved in the cattle production sector:

- MINAGRI and RAB: with a very limited staff should be instrumental to make sure that there will come a cattle sector developmental plan, which entails all aspects of cattle production, which is more than mere genetics.

A Central Identification and Registration system has to be put in place, which is most likely under government control and under RAB- in a National Animal Registration Centre (the current Masaka Semen Production Centre?). This national cattle register is best built up slowly by starting to tag cows that get inseminated and the calves born from such inseminations. The next step is all >75% pure black and white (both Holstein and Friesian type) to be registered into the national black and white cattle register), after which slowly but surely as the vets of the MCCs get a grip on the animals in their area for all animals in the country. This centre should also keep track of all imported, selected to be genetically superior to the local animals, genetic material.

- The 3 research farms with animals will develop their role in overall training and demonstration centres for especially TOT training, so that extension workers, many of them newly appointed after the creation of RAB, get a hands-on experience on livestock. Preferably also farmers from the neighbourhood can receive training in these centres. The centre's livestock should and is already available for experiments but also restocking or improvement of genetics in the villages. These 3 centres should maintain a collection of genetically threatened breeds of pigs, chicken (when found), goats and cattle and exploit these animals through the hospitality industry: tourists would be happy to see these animals in their natural environment and as in Nyanza in the other centres traditional homesteads could be constructed, where some of the centre's workers live taking care of these animals as if they were theirs and to demonstrate to who wants it to see how traditionally cattle are being kept (see further).

Figure 13: Girinka beneficiary (cow not in lactation)

2.8. CROSS CUTTING ISSUES

Genetic conservation

Apiculture

As earlier described there are a number of "ecotypes" of bees in Rwanda, best adapted to the area where they were selected. These should be treated with great care. Any interventions with new/other queens not from the area should be well monitored to see whether it is indeed an improvement. In South Africa the Cape honeybee (Apes mellifera capensis) has developed a sort of "cuckoo" behaviour and is taking over the hives of the African honeybee, Apis mellifera scutellata. Cape honeybees have a considerably lower honey production than the African honeybee. Reports of a high incidence of unproductive colonies or empty hives in the country could have many causes (one of them Varroa infection). It needs to be monitored whether this Cape bee has reached Rwanda, together with the monitoring for the presence and spread Varroa. Therefore it is important to study and describe the characteristics of the 3 "ecotypes" of bees. Queen bee multiplication should be promoted on-site in the 3 demonstration/training apiaries. Laboratory based work on genetic improvement of bees in Rwanda is at the moment not a priority for the sector.

Fish culture

The introduction of new species of fish in natural lakes in the past has led in many places to ecological profound effects. The Nile perch in Lake Victoria is but one example. Was it established that the *Tilapia nilotica* of Lake Albert, with which Rwandan lakes were restocked, was genetically identical or has a new genotype been introduced? Especially with cage farming with exotic genotypes extreme care has to be taken that these fish do not escape and reproduce with the wild population. The YY-male technology will to a certain extent prevent the negative effects of the introduction of new genotypes on the indigenous genetic fish resources. Research is needed to make an inventory of species present and their genetic and ecological relationships for a better understanding of the lake ecology in Rwanda.

Rabbitry

There are no traditional rabbit breeds as all rabbits were imported during the last approximately 100 years. The California/White New Zealand type of rabbits is most commonly seen. It should be established whether there are sub-populations, which have through natural, or active farmer selection diverted from the mainstream and which are worth conserving. The production parameters of such lines have to be established to assess whether they can meaningfully contribute towards the future rabbit production in the country.

It should also be found out, whether there are pockets of rabbit of specific breeds, having been distributed in the past and kept more or less pure. If such breeds have something to add to the above mentioned commercial lines in terms of size (e.g. Flemish giants, Lotharinger etc.), type of hair/pelt (Angora, Rex) these should be described and preserved through the setting up of a breeding scheme, based on utilization of tattoo and doe cards, simple selection and the rotation of bucks between the different breeders.

Poultry

Genetic conservation is only relevant for the family poultry sector. Without knowing what genetic composition after all the distribution programmes is in the family sector it is hard to determine whether there is need for genetic conservation of particular poultry populations in villages. If clusters of chickens with special and useful characteristics of economic importance can be found then it would be important to design a programme to conserve and if feasible use these animals on a larger scale.

Pigs

There has been extensive crossing with imported pigs and locally procured pigs in the country. It is hardly likely that the existing local pig is of a unique breed and therefore genetic conservation could be limited to maintaining a small demo production unit under traditional conditions. Linked to the Inyambo conservation activities in Karama and Nyanza (see further).

Small ruminants

There should come an end to the uncontrolled cross-breeding until it is proven beyond doubt that the cross-breeds are really superior in terms of overall production within the farming system (so NOT on the basis of productivity, but on the basis of overall production) and a clear plan for the next steps after the initial F1 cross have been determined. The existing indigenous breeds need to be better studied and preserved in situ, whereby the community goat and sheep breeding groups will start working on the genetic improvement of the existing population and eliminate the current negative selection for growth rate and early maturity.

Cattle

Genetic conservation of Inyambo and Ankole depends upon making the programme sustainable in economic terms and linked to the overall cattle production system where possible. The adaption of a breed purpose and positive selection for a larger animal with higher adult weight and good fertility will make the breed more attractive for farmers to purchase bulls from the national controlled breeding herds to backcross their Holstein-Ankole/Inyambo cross cows, especially when there is the possibility to enter with government into a contract for F1 production with sexed HF semen.

The Inyambo is a characteristic African breed of cattle, associated with pastoralism. Such breeds are increasingly integrated with wildlife management practices. Without ear tags but with implanted chips not to destroy the natural beauty of the animal herds of Inyambo can graze with the game and become incorporated into the tourism industry and generate additional income to pay for its conservation. In the case of Eastern Province it could be considered to change the existing government research farm into an extension of the national Akagera game park and together with a number of neighbours develop a conservancy, which has as its task to maintain the traditional breeds pure and improve on them and to generate cash from the tourism industry. South Africa

and Swaziland have good examples with their Nguni cattle mixed with wildlife and incorporating tourism revenue into cattle keeping.

There are a number of breeding herds in the region, including an international Ankole cattle-breeding society formed by the various zoos that keep Inyambos. As there is now already a regional study programme under ILRI there are also occasional exchanges of breeding animals between the high officials who keep these animals. Regional collaboration will make the case for the preservation of this breed stronger. The perceived differences between the various lines are so small that it is probably not justified to talk about different breeds. The most important thing would be that this breed gets its economic position in the cattle keeping landscape back before indiscriminate crossing has led to irreparable damage or even loss.

The earlier mentioned National Animal Registration Centre should play an important role in establishing and maintaining these contacts, but also in the promotion of forming a regional register of Inyambo/Ankole cattle. A regionally agreed breed standard will have to be developed.

Research, training and extension

Where research used to be the exclusive domain of academia and research institutions with the advent of FFS's it is acknowledged that also informal off-station research leads to results and potential recommendations for change or adoption as ILRI in the case of livestock has documented in great detail[15]. The gravity point of research is shifting from researcher to farmer: his/her observations are of higher relevance than what is seen on-station under often conditions quite different from farmers' conditions. In the following the main issues for research per species will be described.

Apiculture

There is need for close collaboration between researchers, academia and RAB to come to a joint strategy to answer the existing questions and issues and to communicate these with the farmers:

- Research is needed to study the carrying capacity for bees of the various zones in the country, whereby recommendations can be developed to increase this carrying capacity by planting of e.g. more than Eucalyptus, but also leguminous trees, lucerne as fodder crop for cattle and bees etc. This to be done together with an inventory of existing beekeepers and hives and their distribution.
- Study the various "ecotypes" of bees in the country to better understand their potential and differences, closely monitoring potential invasions with Varroa and/or Cape bees. Genetic improvement is only possible when the current potential and variation in production are known.

[15] http://www.ilri.org/InfoServ/Webpub/fulldocs/AnGenResCD/docs/Workshop_on_Comm_Man_AGR/paper%20Rege/paperRege.htm

- Set up a better hive administration system in a sampling network of performance testing in apiaries in the country with hive cards. This forms the basis of future production recording and selection work. Blanket promotion of beekeeping in the whole country is counterproductive and this point combined with the first mentioned would help to define the exact bee-breeding objective for the coming years: what production capacity can be reached in genetically terms when the restrictions from the environment are known.
- Besides the Ruhande Beekeeping Research Station in the south develop one Research/Training centre in the classical beekeeping areas, where extension workers, FFS master trainers and interested beekeepers can receive trainings. These centres should be preferably privately run with a contract to locally produce new colonies with locally produced young queen bees in a drive to increase the number of genetically superior hives in the zone.
- Develop a FFS approach for improved beekeeping to consolidate and spread the genetic progress; update, improve and print existing written training materials, but with an inclusion of a chapter/section on performance recording and simple selection of genetically superior hives.

Fish farming

The master plan identifies many areas in which research is required: a more regular monitoring of the fish stocks in the Lakes with management plans, setting up local structures for continuous research etc.

There are as yet no productive data of fishponds, which together with the financial and economic aspects can lead to sound business plans, based on real figures, but also provide the feedback to make an evaluation of the performance of the different strains of fish used in fish farming. The quick expansion of the sector merits a far better understanding of all parameters related to fish farming.

Training is required at various levels:

- *Scientists* who will evaluate the different genotypes from abroad, develop and support the YY_male techniques etc. will need to be trained in the common accepted breeding and breed evaluation practices in aquaculture. At the moment the NUR facility in Butara seems the most suitable place for research and training of trainers
- *Extension workers*, existing and future, who are going to work with fish farmers' groups. As part of a general training in fish farming not part of this strategy they should receive training on simple on-farm performance testing through proper recording of some technical parameters during the growing (length/weight of fish, visible mortality, feed used etc.)
- Fish farmers, both the existing and new ones. They will need hands-on training, preferably making use of their own ponds. A Farmer Field School concept would be the most appropriate format to cover the large number of farmers, who need to deepen their knowledge and build more skills in fish farming. Simple production recording should be an integral part of such training as a tool for both genetic and financial analysis.

Rabbitry

Further research is needed on the general environment in which the rabbits have to produce: how can rabbit production be further integrated with kitchen gardens, fishponds, taking genotype-environmental interaction into account.

The principle research in the genetic field needed is a better understanding of the production under traditional conditions of the rabbits and set up a monitoring system in a number of farmers through breeding cards to monitor the effect of the genetic improved animals on overall production. Training can again be organized within the association/cooperative, through the school with rabbitry and preferably in a FFS concept, allowing for local ownership and addressing the issues relevant and of importance for the farmers themselves. On-station rabbit breeding and selection facilities will also create the possibility to run farmer training programmes on rabbit husbandry in the various livestock research centres in the country.

There is need for simple extension messages on hygiene, avoiding of inbreeding, selection of does and bucks and thus extremely simple record keeping. Extension activities could concentrate on going through the large amount of extension materials produced and selecting the best/most effective and develop a set of extension messages to be used during training and in the educational programmes in schools with rabbits.

Poultry

As has been said before there is need to set up a countrywide study to generate a better insight into the productivity and production potential of the village poultry in the various areas to determine whether what generally is called the indigenous village chicken is genetically still the same one after all the infusions with exotic genes. A smart stratified random sampling framework should assist in identifying key villages where a longitudinal study should be set up, with sufficient attention for the socio-economic aspects of the poultry production. NGO's and other development agents in those communities could be useful partners in such study to also be able to measure the impact of their restocking and poultry distribution programmes of the past. Only in this way it can be assessed whether e.g. the introduction of "Kuroiler" will increase production and farmers' income.

For the semi-commercial poultry sector research in the selection of the most suitable type of bird/genetics, considering the easy switch this sector could make between an emphasis on meat or eggs, should be set up, whereby not the production and productivity per animal are the most important but the economic returns per hen housed/animal fed. Appropriate housing systems for the various levels of productivity should be developed and demonstrated to this sector. This sector is a potentially suitable model for rapid rural poverty reduction, if the necessary production model and support structures are put in place.

The village and semi-commercial poultry sector is in need of a location with practical demonstration and training facilities, where extension workers can see

and learn about the various housing systems and management practices in line with the genetic potential of the various types of poultry, where village women can be trained in poultry vaccination, where simple economic analyses can be done on different housing and production systems (e.g. a 50 layers model for poor farmers as an alternative to "a cow per family" in case the family would prefer layers) to determine which genetics will bring the most profitable poultry production model to the smallholders.

Pigs

The research in pigs will have to develop a better understanding and quantification of the current productivity and production parameters achieved in the various production systems, whereby the feeding system in use is the most important determinant of the measured production level. Climatologically Rwanda is very suitable for pig production: no need for heating or cooling and there are sufficient adequate pig housing models in country, so not much research needed there. The major bottleneck in the Rwandan pig sector is proper feeding with available resources and the selection of genetic material for improvement should take this into consideration, considering the strong genotype-environmental interactions existing between husbandry/feeding and production. Only after comparing the performance of animals under different husbandry systems and feeding regimes can the best genetics for the country be determined.

Small ruminants

As earlier said the research in small ruminants will have to reorient itself to building up a far better understanding of the production and productive capacity of indigenous sheep and goats under improved conditions, but also under the existing conditions. This should then be compared with the performance of so-called improved animals and their crosses on and off- station. A simple doe/ewe breeding card system, introduced by the extension services and filled out by farmers (preferably linked to an animal identification system) will be instrumental in being able to do this.

Cattle

The research into cattle seems so far to have been mainly the maintaining of the Inyambo and Ankole breeds and for the last 13 years studying the results of crossbreeding Sahiwal, Holstein and Jersey with Ankole and the body weight and milk production of the various crosses F1 and F2. The numbers of animals used and the specificity of working on a research station mean however that even if there are any results being published these cannot be transferred to the farmers' situation as most farmers are working with animals under zero-grazing: the environmental differences are too big to apply the conclusions of an on-station grazing system with an on-farm zero-grazing system.

Future cattle research should be more geared towards supporting the development of a viable zero-grazing cattle production system, with input output studies, not only in terms of money but also minerals, labour requirements and

profitability of such a system under the prevailing and future conditions. The generated information can also give an evaluation tool to determine which genetics are the most suitable for the zero-grazing model with fodder and feed constraints.

The upcoming beef industry will need research into the suitability of the various crosses already being used under the existing availability of feeds and fodder and under the conditions with the use of a low-cost fattening ration consisting of urea and by-products. Besides this genetic evaluation under different management and feeding regimes (so not only on-station) research into strategic supplementation of cattle in dry periods and droughts should form the key to determine the best way forward for the development of Rwanda's beef production sector.

The RAB and MINAGRI staff will need training to run modern cattle development programmes, based on farmers' ownership with the government officials in the role of facilitators. Especially the understanding of and attention for the economic aspects of production need to be increased dramatically. Ministry staff and researchers should be able to work out simple adequate performance testing programmes as the basis for genetic selection, formulate together with stakeholders breeding purposes and plans and communicate these with the respective MCCs/cattle registers/future herd books.

Continuous training of the current AI inseminators is required, especially when their task is widened with Identification and Registration, herd book registration, facilitation of cattle trade etc. With a working Identification and Registration system, reporting on inseminations and births related to a cow's number would give a possibility to monitor the performance of the inseminators, record the pedigree of calves and create an incentive to improve their performance. A system of licensing of inseminators should protect farmers from malpractice and give the government some guarantee that investments in either production of semen or imports are used in the best possible way.

There is need for the development of demonstration/research models of small dairy farms with zero-grazing on the existing research farms, where e.g. a worker of the centre emulates a small-scale dairy farmer and assists the researchers in generating the data to better understand this production model and work towards technical interventions at a farming system level that can maximize the returns farmers get from their livestock. Such programmes would require a multidisciplinary team to work on this: comparing rubingo with e.g. a Rhodes Desmodium mixture, feeding of only maize bran with one of feeding with a more complete feed etc. etc. Only in this way, combined with the off-station data collection, can a meaningful analysis of the genetic potential of the various dairy crosses under different management systems be made with the exclusion of genotype-environmental interactions.

Commercial dairy farming based on grazing is relatively new to Rwanda. The dairy farmers in the lowlands in the neighbourhood of Kigali can improve their farm operations in many areas. The limiting factor is that most are absent farmers as they have other occupations and thus little to no active management

decisions on selective breeding and reproduction are made. A group of these should come together and employ an experienced dairy farmer, e.g. a Zimbabwean who lost his dairy farm, who is fully aware of the latest technologies and insights in dairy farming to become a coach/proxy manager of a number of these farms and advise on and monitor interventions to improve productivity and overall production, whereby selective breeding using compensatory breeding bull choice decisions will form an important instrument to increase uniformity and productivity. Such a person could in a few years' time at minimal to no (owners pay) cost to government make a large difference to the general dairy farming practices in this sector and show the effect of the right bull selection for different types of cows on daughter productivity and uniformity.

2.9. Organizational aspects to facilitate AGI

Apiculture

There are a large number of organizations operational within the beekeeping sector, which through an update of the strategic sector plan could better define their collaboration. Within the past ARDI and currently SNV the de-facto sector leader but soon withdrawing from beekeeping activities it will be important for the sector to discuss which organization will be the "value chain leader". A revision and updating of the beekeeping strategy could be the trigger to bring organizations closer together and create more cohesion and collaboration. The initiation of this process should be the combination of the RAB and MINAGRI responsible people for beekeeping. Only with a strong organizational basis would it be possible to promote a wider use and penetration of locally selected superior genetics in the overall bee population.

Fish farming

The sector is young and still needs to develop its organizational structure to take over from PAIGELAC and other projects' sector management. Formal links need to be established between fish farmers and fish farmer cooperatives/associations on one side and the producers of fingerlings on the other side, so that both parties' businesses are linked and secured. Pricing mechanisms for fingerlings, which guarantee quality fingerlings to the fish farmers but also sustainable business prospect to the hatcheries will be, together with a rapid development of a value chain and markets, both in-country and out of country, key to the continued post-project development and expansion of the fish farming sector.

Rabbits

There is currently no organisation operational for the rabbit sector. There is however need to build up such an organisation, to maintain the genetic centres and make sure that there is regular exchange of breeding material, coordination of training and exchange of information. Especially the links with Ministry of Education and Agriculture have to be strengthened to make rabbit production again part of the school curriculum and schools actors in the promotion of rabbit keeping and distribution of superior genetics. The best way to achieve such coordination and exchange would be to form a rabbits "working group" to come up with a sector plan, in which both the public and private stakeholders,

especially the many NGOs, have their defined role. The RAB and MINAGRI responsible persons for rabbitry can take the initiative to organise such a working group, leading into a strategic plan for the promotion and improvement of rabbit production. Genetic improvement has the best results in large populations with committed breeders: a network of schools with committed pupils and teachers will exactly form such a basis.

Poultry

The country has a poultry association, which unites a number of commercial poultry farmers, but does not count with private feed millers and representatives of the mini-hatchery cooperatives and village poultry farmers. For the association to be more representative to the whole sector it would be advisable to expand its membership and include representatives of NGOs active in village poultry production (e.g. VSF), representatives of projects (e.g. APEL) and veterinary suppliers in the organization. The association, together with RAB and MINAGRI responsible people should work on a sector development strategy plan, in which further details on the provision of genetic material, quality feed and control of the markets are the three key aspects.

Pigs

The pig sector is without any organization, jeopardizing any initiative for genetic improvement, but also the development of working value chains. At the moment commercial pig production does not seem to be profitable, which is another impediment to sector development. A working group should be formed to tackle the issues of genetic improvement, feed manufacture, value chain development, training and demonstration sites locations and organisations. Only when within the chain there starts to be a dialogue between the various stakeholders can the situation improve and the genetic improvement become profitable.

Small ruminants

The research institutes working on goats have too little connection to the farmers keeping goats, where valuable information on the goats' performance can be collected. With the formation of village goat breeding groups/FFS's this can change and a national platform for small ruminants can be established. From such initiatives flock books for the various breeds could be started and maintained.

Large ruminants

There is currently no cattle producers' association. There is however a number of dairy farmers, who have shared interests which would be best taken care of by a national dairy association, which unites all the local dairy associations/cooperatives. The central point of organization for dairy farmers is the milk collection centre. There is now a National Dairy Development Board, which should form the bridge between the farmers' organization and the government. All of these organisations are still very young and would still need support to fulfil their role for the development of the sector. From these organisations the interest to form a Rwandan herd book for the various cattle breeds should be developed.

The beef sector is unorganized and mainly based on the local breed and crossbreds. With the advent of cross-breeding with Simmental/Brahman/Beef master/Boran it would be good to form a beef farmers' association, which will defend the interests of beef farmers, take responsibility for the training on good farming practices, prevention of diseases and collection of data to assess the productivity of the various breeds and crosses. Such an organisation can consist of the various beef farmers' FFS's coming together.

2.10. Livestock in poverty eradication

The Rwandan government at an early stage acknowledged the potential of livestock for poverty eradication and has made this a spear point in its government programmes. The flagship Girinka programme, in which poor people are given a pregnant heifer to be kept under zero-grazing has covered more than 100.000 families and many more are foreseen. The Girinka programme also has a positive effect on the agricultural production of these families through the manure. With the current level of genetic potential distributed (many animals < 50% dairy breed), the often deficient nutrition in both quantitative and qualitative terms and the difficulties in the dairy sector the economics of this zero-grazing model have to be carefully assessed. The choice of the right breed or cross for restocking can be distilled from the mid-term Girinka evaluation currently underway.

Distribution of goats and especially dairy goats has proven even more successful than dairy cattle distribution to the poor, although not as yet well documented. The mid-term review of Girinka underway now should shed light on the success-rate of this cow distribution model and could maybe also have a look for comparison's sake at the goat distribution model. The Saanen initiative in Eastern Province and Alpine in northern and Western Provinces should be carefully studied and fine-tuned to avoid possible shortcomings in future. The introduction of these dairy goats increase the returns poor people can generate from their local goats through gradual crossbreeding with the larger, more prolific and milk producing dairy goat breeds, if at the same time forage and feed availability and quality improve.

Other models, when the commercial poultry sector and feed industry develops, would be small units (50-100 layers, 200-500 broilers) of commercial poultry, preferably embedded in a value chain through which feed, DOCs, advice and veterinary care and most importantly markets, will be assured. Rwanda seems to be due to its geography and demography ideal for semi-commercial smallholder poultry production. Large-scale poultry production runs into planological difficulties due to the lack of suitable land for such developments.

All poverty alleviation models should assure asset building and generate recurrent income, with which people can reinvest and cover their household expenses. It is for these reasons that dairy, egg production, broiler production and goat fattening fit in better than e.g. fish farming or goat rearing due to their longer cycle before returns can be generated. It is therefore also advisable that Girinka heifers are at least 50% exotic breed and guaranteed pregnant, so that

the flow of revenue starts soon after distribution and people generate cash, which they can utilize to maintain their cow.

2.11. Legislation for AGI

The lion's share of legislation in the field of livestock is usually veterinary and concerns the control and eradication of animal diseases and food safety. Besides these veterinary laws most countries have additional legislation to regulate animal breeding, trade, systems of carcass classification and standardized weighing, animal welfare etc.

This livestock legislation can be developed in two ways:

- *Separate laws for each subject*: every piece of legislation has to be passed by parliament, which is a time consuming process and is often hindering timely legislation in case of emergencies etc.
- *Framework law*: in broad outlines the various aspects relating to animal production are mentioned and per section the competent body is indicated (in most cases MINAG) and the institutions responsible for the execution of the in the law stipulated points. The minister or head of veterinary services can then issue regulations for each of the points mentioned in the framework without having to seek parliamentary approval

The second option is usually preferable as it allows for a quick process of legislation through the issuance of regulations by the minister of agriculture without parliamentary approval as they approved already the framework law on the general principles. That means that the framework law should cover all important issues and define who decides, who supervises, how sanctions are applied and who enforce the law and regulations.

The following points should be included in any livestock law:

Title of the Law
Definitions: an important point is to give an exact definition of all terms so that there is no reason for confusion and disputes. For all elements of the law these definitions should be given
Purpose of the law: A livestock law has normally one overall purpose, the promotion of livestock production in the territory to which the law applies. Specific purposes could be:

- To facilitate the free movement of animal genetic resources. This is an important element for e.g. the EU. Many EU decisions have been dedicated towards the mutual recognition of herd book registration and selection results to facilitate the free movement of pedigree animals across the borders
- To improve the genetic potential of animals in the country
- To safeguard endangered or rare livestock breeds
- To regulate the quality aspects of imported and distributed feed stuffs, especially in terms of food safety and correct labeling

- To regulate the relationship between farmers and processors in terms of standardized weighing and carcass classification to promote a payment system based on quality and quantity
- To set zoo technical standards
- To define rules for animal welfare in terms of housing, transport and humane slaughter
- To regulate the disposal of animal waste and protect the environment
- To regulate issues of communal grazing on state land: leasing, organization of livestock keepers on such pastures
- To set standards and rules for animal identification and registration, this is not necessarily only an official state system but could also be the depositing of owner specific brands

Chapters on the various technical sections of the livestock law:
- Animal breeding
- Feedstuffs
- Trade in livestock and livestock products
- Quality standards and control mechanisms
- Zootechnical standards
- Animal welfare
- Environmental protection
- Communal grazing and pasture leasing
- Animal Identification and Registration

Relevant to this strategy is the section on animal breeding, quality standards and control mechanisms and animal identification and registration.

Under animal breeding the law should regulate how new genetic material is authorised to come into the country, who is entitled to collect and sell semen and from what animals, who can do inseminations and what are the minimum standards/requirements, the pedigree registration mechanism and the recognition of breed associations and their herd books, the right to issue pedigree certificates and how performance testing and genetic evaluation will be done. Quality standards and control mechanisms are a broader area. Here it is e.g. determined to what extend the country in its AGI will comply with organisations like ICAR (International Centre for Animal Recording)[16]and its sub-committee Interbull for the standardisation of the evaluation of breeding bulls. Animal identification and registration when passing from voluntary measure to compulsory would need a legal basis, which can be included under a framework livestock law. It could be foreseen that the National Animal Breeding and Registration Centre will have an important say in how such livestock laws could look like. The EU "set" of laws can be found on http://ec.europa.eu/food/animal/zootechnics/index_en.htm.

[16]www.icar.org

Strategic options and plan for AGI in Rwanda

3. Strategic options for animal genetic improvement

3.0. Overview

The overall purpose of the genetic improvement strategy in the TOR is defined as:

> "To contribute towards improving the efficiency/productivity of the animal resources subsector in a sustainable manner, promote public health and support marketing of both livestock and livestock products to contribute to the national efforts in poverty reduction, improved food security and income to the satisfaction of the expectations of key and subsidiary stakeholders"

This is the description of the larger contribution of genetics towards the overall increase and improvement of animal production, which is far more and quicker brought about by improvements in overall animal husbandry than from genetic improvement. For the genetic improvement strategy a more focused objective would be:

> "To select and/or create the most suitable genetic material with which farmers will be able to achieve the highest returns under the management and environmental conditions in place from their livestock when the offspring of the animals in the genetic improvement programme start to produce".

This objective takes the highest possible financial returns as the key driving factors for genetic selection, improvement and above all drastic improvement of general husbandry. The impact of all of this can be seen rapidly in rabbits (6 months), but with cattle it takes at least 3-4 years before the effect of AGI is visible in e.g. increased milk production.

The strategic options for the AGI are threefold:

- Develop improved understanding of actual production and genetic potential and monitoring system to measure on-going and future improvement
- Increased human capacity for research and extension in, services to improve and management of animal genetic resources
- Private sector driven and managed breeding plans with the government in a regulating and support role

These three strategic options can be translated in the following specific objectives of the genetic improvement strategy, grouping the action points earlier mentioned in the report under 6 headings as follows:

1) Baseline study and monitoring system:
   Create a sound understanding of current productivity levels of animals and set up a system to continuous monitoring the impact of the genetic improvement on production under the on-going improvement programmes;

2) Research and Extension:
   Develop a joint research and livestock development programme between MINAGRI, RAB and Agricultural universities, client oriented and solving pertinent problems and shortcomings in the livestock production systems;

3) Develop breeding plans:
   Adopt breeding systems based on clear breeding objectives, breed standards and a system of performance testing of animals, which will facilitate the selection of the genetically superior animals and create genetic progress;

4) Organizational development:
   Promote and organize the right organizational frameworks at both national and village level, through which improvement of livestock production, including genetic selection and reproduction, is organized and executed;

5) Capacity building and participation:
   Increase people's knowledge and understanding of genetic animal improvement and increase their role in the process;

6) Conservation of animal genetic material:
   Develop a sustainable programme for the genetic conservation of indigenous breeds of farm animals.

In the following the general activities and budget estimates for the various activities foreseen will be given. The detailed interventions suggested per species are described in section 2 (and annex 5) and will not be repeated in this section. The working groups that will formulate the detailed breeding plans, research and training strategies can refer to the respective sections on each species to include these.

It should be kept in mind that many of the activities suggested here are actually activities, which on paper exist, but in reality are poorly or not executed and will have to be improved as part of achieving animal genetic improvement. The collaboration with the private sector needs to be built and strengthened to reach the objective of animal genetic improvement: future higher income for livestock

farmers from their livestock. It is obvious that the 4 strategies developed for meat, small livestock management, poultry and animal genetic improvement are all overlapping and should be reworked to one overall livestock sector development strategy, whereby the recurrent budget is included with the more investment budgets as drawn up in these strategies.

3.1. Baseline study and monitoring system

Objective: Create a sound understanding of current productivity levels of animals and set up a system to continuously monitor the impact of the genetic improvement on production under the on-going AGI programmes

Activity	Budget (1000 $)	2012	2013	2014	2015	2016	2017	2018	Participants	Priority	Rwanda Contribution	Private sector Contribution	Partners of development Contribution
3.1.1. Baseline study on-farm production and current productivity	50	X	X						RAB/Universities Research Inst, Local Government	high	25		25
3.1.2 Registration and monitoring system of performance of the various animal species	55		X	X	X	X	X	X	RAB, National Animal Breeding and Recording Centre, Herd /Flock Books	high	50	5	
3.1.3 Systematic recording+ publishing/communication of the outcomes of performance recording, crossbreeding research and analyses	55		X	X	X	X	X	X	MINAGR/RAB	Moderate	50	5	

3.1.1. Baseline study on-farm production and current productivity

This activity would be under the responsibility of and forms part of the regular duty of RAB national and district staff and should be developed in collaboration with the Agricultural Faculties of the various universities. It will give valuable information on actual productivity and production levels and take out a lot of uncertainty in planning due to more reliable data and increased insight in the production system. This has to become part of the regular tasks of both researchers and RAB staff to continuously monitor. There are no budgetary implications foreseen other than transport facilities and running costs as this can be considered part of the core-activities of RAB and the various agricultural faculties. The baseline study will take 1 year and pilots and tests methodologies for improved continuous monitoring of livestock performance, which will then be used afterwards in activity 3.1.3.

Activity 3.1.2 Registration and monitoring system of performance of the various animal species according to a predetermined method

For the various animal species performance measuring and recording systems have to be put in place to enable selection, but also to produce better statistics on animal productivity and overall production. With simple systems to record e.g. honey production per hive and period, weight of fish harvested per pond, egg production per hen housed, slaughter weight of carcasses in determined periods of the year etc. valuable data for further analysis can be collected. The reporting system should be standardized and simple and related to participation in national animal improvement programmes: The beneficiaries from government's distribution programmes of improved genetics will to the best of his/her capacity participate in this activity to support the better understanding of the impact of such distributions on productivity. To measure the effectiveness of a genetic improvement programme regular measurement of production and productivity should take place, not only on-station but also under farming conditions. This is a system in which the global production of a farm can be monitored and is a continuation of 3.1.1, which establishes the baseline against which the progress will be measured and develops and tests the methodology how this can be done.

Activity 3.1.3 Systematic recording and publishing/communication of the outcomes of performance recording, crossbreeding research and analyses on a MINAGRI/RAB website and in farming press and/or information bulletins.

As a service to farmers information generated from data collected from farmers by RAB and Universities should be analysed and made publicly accessible as soon as possible. In the current situation most data are used for a limited number of scientific publications, which is not a basis on which you can ask farmers to participate in data collection. An honest comparison of performance of various breeds and crosses will give livestock keepers the possibility to make the right choices for their farms. Timely publishing of research results will also become a management tool to fine-tune policy decisions on e.g. further import of certain breeds or semen of such breed, the best locations where certain species can be used etc.

3.2. Research and Extension

Objective: "Develop a joint research and livestock development programme between MINAGRI, RAB and Agricultural universities, client oriented and solving pertinent problems and shortcomings in the livestock production systems"

Activity	Budget (1000 USD)	2012	2013	2014	2015	2016	2017	2018	Participants	Priority	Rwanda Contribution	Private sector Contribution	Partners in development Contribution
3.2.1 Develop a research and development agenda per species, for improvement of productivity and production	50 (TA) + Recurrent	X	X						Consultant, RAB, MINAGRI, Research, Universities, farmer reps.	High			50
3.2.2 Build up collaboration with the livestock keepers to partake in animal husbandry and genetic improvement research	Recurrent		X	X	X	X	X	X	RAB, extension, farmer organisations, Research, universities NGOs	Medium			
3.2.3 Create strong links to the extension services to identify problems, to field-test possible solutions, formulate extension messages and to communicate results	Recurrent	X	X	X	X	X	X	X	RAB, NGOs, FFS, MINAG, Research and Universities	Medium			

The collaboration between MINAG, RAB and research institutes/universities is crucial to solve issues and problems in the livestock sector and should be well defined to create synergy and results. Research should be adaptive, client oriented and solving pertinent problems and shortcomings in the livestock production systems with executable recommendations.

Activity 3.2.1 Develop a research and development agenda per species in which genetic improvement is but one integrated aspect, to resolve the bottlenecks for improvement of productivity and production

Genetic improvement on its own will not improve animal productivity and production. In a joint effort researchers and specialists of MINAGRI and RAB will have to in an interdisciplinary way find solutions for existing problems in the husbandry of the various animal species. The development agenda, making specific choices, has to be based on proven facts. In the separate chapters on the various species research needs have been identified. These range from veterinary (e.g. Varroa control and prevention), feeding (especially the monogastric animals) to marketing and economic ones (e.g. the current poor profitability of milk production). Through such an approach it is hoped that there will come more cohesion between academia, policy makers and the policy implementers to speed up the process of research, results and application on farm.

Activity 3.2.2 build up collaboration with the livestock keepers work through their own organisations to partake in animal husbandry and genetic improvement research

Almost all livestock breeds in the world are a result of the empirical work of farmers. There is no reason why this capacity to select and improve animal genetics cannot be enriched with modern insights in animal genetics and to be utilized for the on farm improvement of livestock owners' animals. Especially in a situation with high variability within the population simple selection will be bearing results. In pilot programmes the collaboration between farmers, researchers and ministry staff is built up to solve pertinent problems through research, field trials and demonstrations.

Activity 3.2.3 Create strong links to the extension services to identify pertinent problems and constraints, to field- test possible solutions, formulate extension messages and to communicate the outcome of the client oriented research through extension to farmers

Researchers must be fed information from the field on issues and problems bothering farmers to set their research agenda. The development of solutions to identified issues and problems will usually be a combined on-station/on farm effort and will always be a range of interventions. The FFS's will play an important role and share their own research outcomes with the scientists, who can together with the extension services facilitate the research/discovery/testing process.

All of this activity is a reorientation of current approaches towards research, to develop new ways of setting the research agenda (addressing issues and problems brought from the field) and incorporating farmers' capacity to test and research through their FFS's and other organisations within the overall research work. It should as such be included within the recurrent budgets for extension and research and does not merit a separate budget under the genetic improvement strategy.

3.3. Develop breeding plans

"Adopt breeding systems based on clear breeding objectives, breed standards and a system of performance testing of animals, which will facilitate the selection of the genetically superior animals and create genetic progress"

Activity	Budget (1000 USD)	2012	2013	2014	2015	2016	2017	2018	Stakeholders	Priority	Rwanda Contribution	Private sector Contribution	Partners in develop. Contribution
3.3.1 Formulate for all species a breeding plan with objective, breed standard, registration requirements, in consultation and with agreement of farmers	50 + recurrent	X	X						Consultant, RAB, farmer org.	Medium	Recurrent		50
3.3.2 Expand the current I&R system and the processes of data transfer	180-230 + recur.		X	X	X	X	X	X	NABRC, RAB, vet services, MCCs	Medium	Recurrent (60)	Cost Rec.	120-170
3.3.3 Build up and maintain a strategic stock of gen. material as live animals, semen and possibly embryos.	100 + recur.	X	X	X	X	X	X	X	RAB, NABRC, later herd books	Medium	20	10	70
3.3.4 Set up a system of performance testing, analyse data and provide feedback to the owners	100		X	X	X	X	X	X	RAB, NABRC	High	50		50

In animal selection it should be clear what type of animal one has in mind as the ideal: this is the breed standard. The environment in which such an animal is expected to produce is an important determinant to decide on which type or breed of animal is the most suitable. Only in such a way the selection of the animals to produce the next generation, which will be more productive and/or profitable for farmers to keep can be set up. Besides the breed standard one would need proper animal identification and registration systems for a more scientific underpinning of farmers' common selection practices, which will remain the first line of animal genetic improvement.

Activity 3.3.1 Formulate for all animal species a breeding plan with the breeding genetic improvement objective, breed standard, registration requirements, in consultation and with agreement of the livestock owners involved in that breed and interested to participate

There is an increasing realization that under most ecological and management conditions the introduction of exotic genetics has been disappointing in its purebred form; the possible positive effect of the cross-breeding wears out in the next generation as large part of the positive effect is usually caused by heterosis. Uncontrolled crossbreeding can even make the animals less resistant to the often-prevailing adverse conditions such as drought, fodder of low quality and feed shortages or parasites and diseases. Together with farmers a new approach towards animal breeding has to be developed to introduce selection for productivity and controlled reproduction to increase the frequency of desirable genes in the population. This can be achieved through adopting a breed standard, a clear breeding purpose, of which in section II examples per species have been given and agree with livestock keeper son the selection and breeding programme, some simple data recording mechanisms and collaboration between farmers and RAB on data collection and exchange.
With the assistance of ILRI/FAO MINAGRI/RAB has to develop the knowledge, skills and facilitating attitude in its staff concerned to develop, together with the livestock breeders such breeding plans. In section II suggestions for selection criteria and breed standards have been given, which have to be further detailed in consultation with farmers involved. These must be discussed with farmers and agreed upon, after which the breeding plan for the various livestock breeds in the country can be further developed.

Activity 3.3.2 Expand the current animal identification and registration system and automate as much as possible the processes of data transfer

An I&R system is an important management tool for farmers to individually recognize their animals when they have many and for outsiders (e.g. the vet services or researchers) to differentiate between animals and for proper data identification and storage. An animal identification and registration system will only work if there are mechanisms to incorporate all mutations in the database regularly: births, animals sold from one holding to another, animals dead or slaughtered. In most countries the setting up of such a system starts with great enthusiasm, but turns out to be hard to and mainstream it in the general animal husbandry system and maintain after initial usually project based investments. The preconditions for maintaining the integrity of the animal database is good

legislation to enforce it, trained officers (veterinarians) in the field to tag and capture the mutations and an effective data capture, transmission and verification system, leading into an up to date database programme, which can produce a wide varieties of reports. It should be agreed that Rwanda would use the ICAR and ISO standards for an animal identification and registration (I&R) system to be developed. It is a major challenge to build up such an I&R system and it will require a phased approach to build it up. The first step can be to task the veterinarians and inseminators to tag any cow that they inseminate with the proper Rwandan country tag, containing according to ISO country code, area code, holding code (could be the MCC), individual unique number and a bar code. When a calf from insemination is born this calf is tagged by the same inseminator/veterinarian, who will vet that it was born within the likely time range after insemination. Inseminators should be equipped with a Personal Digital Assistance (PDA) with a scanning and G3 communication capability to send the data to the central database. On this database a specialized database programme for animal identification and registration, pedigree registration and performance recording is running[17]. Such a programme should have 3 data input ways: through Internet, through PDA's with 3G capability and manually in the data centre through keyboard, but preferably the last as little as possible. The best is to purchase an existing modular animal identification and registration software programme, to which additions can be made if and when required. In this way, the programme can also be used for veterinary purposes (movement control, disease control monitoring), veterinary sero-surveillance and vaccination data transmission (sample registration, reporting back on animals vaccinated), quality control of AI (check insemination against birth reporting), improved livestock statistics (better information on how many animals there are) and would develop into a Management Information System for RAB animal production department.

The focal point for this identification and registration system should be the veterinarian/inseminator, linked to a MCC. He/she will record all mutations and transmit to the central database. After incorporation and verification within the system an overview of animals present in that MCC will be sent back as a management tool. Insemination data are incorporated, giving the possibility of producing alert lists for checking for recurring heat, upcoming calving etc.

Gradually this system of animal identification and registration should be expanded to pigs, goat and sheep and cover all these animals, so that the country has a complete database of animals present. This will be an excellent planning tool for veterinary follow up and monitoring, control of breeding and quality. For the livestock owners it would be an anti-theft tool when all animals are tagged: any animal with perforated ears but no tag is suspect of having been stolen and would merit further investigation and any movement permit can now be "tied" to specific animals through mentioning the tag numbers on the permit.

[17] An example of such a programme can be found on http://www.interagri.org/E/LivestockDatabase.htm

Activity 3.3.3 Build up and maintain a strategic stock of genetic material of the various species in the form of live animals, semen and possibly embryos.

There have been a considerable amount of imports of pigs, goats, sheep and cattle, of which it is now very hard to say where they have remained and what their impact on productivity and production have been. Such animals should be identified and registered, so that they can be monitored. The earlier mentioned management plan of genetic resources per breed should help to assure that imported genetic material is kept pure, that there is selection and reproduction within such a nucleus and that there can be proper performance testing. Through the formation of herd and flock books, related to a breed standard and breeding plan, animals can be kept pure and continuously improving through selection.

The country produces its own bull semen for 3 breeds and does around 60-70.000 inseminations per year. The technical results of these inseminations are hard to measure: inseminators say 70-80% pregnant after first insemination, RAB officials from Masaka Bull Station mention 50% and farmers indicate 20-30%. Genetic progress will be highest if every year a selection of semen from test bulls from a country with a large genetically active population and a modern breeding programme, which in theory should have the highest genetic value, would be imported. This is however a question whether as a country one would mind to being dependent on imported semen only (the number of potential suppliers of Holstein semen is large.)
AI in cattle should be with a simple catalogue explaining expected production and exterior transmission so as to give livestock owners a choice and say in the matter of fertilizing their cows. For Girinka cows the use of sexed semen should be promoted to increase the speed of passing on heifer calves and the chance that such a cow will breed her replacement timely.

Embryo transfer for the Rwandan dairy sector is hard to justify in terms of cost benefit; embryo collection and storage of the best Ankole/Inyambo cattle is justified in terms of genetic conservation and exchange with other countries.
It should be carefully calculated whether in the long run it would not be better to purchase Jersey/Brown Swiss/Holstein semen from abroad instead of local collection: currently twice more is collected than used, bulls are genetically speaking yesterday's generation, whereas with purchase of semen a wider genetic range and more up to date genetics can be used.

AI for pigs is a good way to spread the genes of genetically superior pigs within the existing population, where management is of a high enough level for animals to express this genetic potential. In the north there is already a small pig AI Centre equipped and ready to roll. For the central and Southern Part of the country a small facility can be created at the Masaka Bull Centre, which then better be renamed into the Masaka Animal Breeding and Recording Centre. In annex 6 an example of the running costs of such an AI centre with 10 boars is given. Boars will have to be imported and a simple boar station constructed. It is however doubtful whether with the current profitability of pork production such a development should be a priority at the moment. First priority would be to organize the sector and create sufficient critical mass of progressive commercial

pig farmers interested to use such pig AI services when payment is required before investments in a pig AI breeding centre will be made. At the moment pork production for the market with modern pigs and feeding commercial feed is not profitable. Pig farmers still doing so have either their own outlets for pork in shops, restaurants or sell breeding stock to newcomers to the sector. The number of discontinued pig farms is rather large at the moment.

Activity 3.3.4Set up a system of performance testing of individual pedigree animals, analyse data and provide feedback of the results to the livestock owners

This activity at this stage would be most feasible with the dairy farmers around Kigali: with proper performance testing of pedigree/registered dairy cattle, it would be possible to calculate breeding values of individual cows, but also compare between the various farms. The information generated from the performance testing would form an instrument to improve management and to select bull mothers for the production of young bulls for areas where AI is not successful or without reach. The National Animal Breeding and Registration Centre, in charge of maintaining the Identification and Registration database and artificial insemination data will also record the data of performance testing so that all information on individual animals is concentrated in one place. Simple methods of breeding value calculation will be applied here and feedback given to farmers.

The inseminators/inseminating veterinarians will be with their PDA be the data entry point for I&R, AI and performance testing. Farmers will be provided with the outcome of the performance testing and simple breeding indexes, based on financial returns of the animal, will be communicated back to farmers.

This activity would need technical assistance to set up, for the training of people involved and monitoring during at least the first 2 years. It would result in a system for animal identification and registration, AI and production performance recording, which all together will give the instruments to start a science-based animal genetic improvement system and move away from the import of genetic material.

Some budget details:

Item	Units	Unit price	Total	Remarks
Computer hardware	1	20.000	20.000	Input and storage computers
Animal I&R computer software		50.000-100.000	50.000-100.000	Customized existing modular software programme
RFID [18] implantable	1000	4	4000	Implant, for esthetical pur-

[18]Radio Frequency Identification, sometimes referred to as the implantable chip

chips for Inyambo				poses
Readers RFID tags	5	200	1000	One for each Inyambo herd and one for RAB
Personal Digital Assistants	200	200	40.000	Data entry for veterinarians + inseminators
Communication Costs	Lump sum		20.000	For PDA's and internet access
Printed cattle tags	100.000	0.4	40.000	Inseminated Cows + calves born from AI
Printed small ruminant tags	10.000	0.35	3500	Registered flocks/ import animals
Application equipment	Lump sum		10.000	
Import semen				See Min. budget
Boran/ Sahiwal bulls	3	10.000	30.000	MINAGRI/farmers to decide breed
Import breeding boars	Lump sum		15.000	See APEL plans
Import pig AI equipment and consumables	Lump sum		10.000	
Import small Ruminants for nuclei				See small stock management strategy
Dairy manager	1 year	75.000	75.000	To be paid after year one by dairy farmers themself
TOTAL			**315-365.000**	

3.4. Organizational Development

"Promote and organize the right organizational frameworks at both national and village level, through which improvement of livestock production, including genetic selection and reproduction, is organized and executed"

Activity	Budget (1000 USD)	2012	2013	2014	2015	2016	2017	2018	Stakeholders	Priority	Rwanda Contribution	Private sector Contribution	Partners in develop. Contribution
3.4.1 Establish livestock breeding groups at village level	100 + recurrent	X	X	X					RAB, NGO's, Extension, Farmer org.		Recurrent		100
3.4.2 Promote the formation of registers, herd and flock books as private entities to maintain and improve existing and imported breeds of livestock	50 + recur.		X	X	X	X			RAB, district vets, MCCs				50
3.4.3 Form the National Animal Breeding and Registration Centre for support and service provision to the individual flock/herd books and breeding groups	170 + recur.		X						RAB, Research Pedigree farmers		50		120
3.3.4 Set up a system of performance testing, analyse data and provide feedback to the owners	50+ recurrent		X	X	X	X	X	X	NABRC, RAB,		50		

Livestock husbandry and breeding requires organisations at both national and village level, through which animal selection, extension and farmer training are organized and executed. Public private collaboration is required at many levels and should be defined and strengthened. The following proposed activities aim at developing such organizational structures and mechanisms for the collaboration between public and private sector.

Activity 3.4.1 Establish livestock breeding groups at village level, feeding into objective 3.3 (controlled animal breeding systems for pure-breeding, cross-breeding and selection)

As said earlier in the African livestock populations with high levels of variability farmer managed selection can create quick genetic improvement in the various performance characteristics such as growth, vitality and fertility, leading to higher returns for farmers from the next generation of animals. Especially in goat and sheep farming the current negative selection for growth by selling the fastest growing rams and billies the first has to be turned around into a positive selection for growth and early maturity/fertility by selecting these for breeding. The same approach can also be used in rabbit and pig selective breeding. The APEL project gave many examples of paper registration systems of animal performance on which this selection can be based[19]. RAB facilitators working with such FFS/community breeding groups will work together with the veterinarians on the animal identification and assist the people in registering, weighing and measuring animal performance. This information will be communicated to the National Animal Breeding and Registration Centre in case of pedigree animals, otherwise data can be analysed locally and the information used for animal selection decisions.

Activity 3.4.2 Promote the formation of registers, herd and flock books as private entities to maintain and improve existing and imported breeds of livestock

In the current situation imported purebred/pedigree animals "disappear" in the overall gene pool. The envisaged National Animal Breeding and Registration Centre, together with RAB's veterinarians, will start to identify and register these animals (preferably registering animals from earlier imports and re-identifying them with Rwandan tags and registration with pedigree information from country of origin) within the National Animal Registration database. In the long run however the responsibility for the maintenance and improvement of the various breeds should shift from government to private structures. The most likely breeds to be incorporated in such an exercise are the black and white dairy cattle on the larger farms around Kigali. These farms are within reach of RAB officials and with owners who would see their own benefits in creating a Rwandan Holstein Frisian Herd book and Register (for the currently non pedigree, but breed specific animals to reach 3 known generation pedigree status) and gradually take over tasks for the improvement of the breed from government by forming their own herd book organisation. Elsewhere in the world pedigree animal breeding is a private good.

[19]APEL (2010):"étude relative a la mise en place d'un système d'amélioration génétique des animaux à cycle cours"

Another candidate for a herd book is the population of Inyambo and Ankole: after defining in consultation with the owners the breed standards and registration requirements the existing population can be included in the National Inyambo and Ankole register/herd book to be formed. This will be a "club" to improve and maintain the breed selection programmes as described in Section II so as to maintain and improve the breeds for the characteristics as determined.

The existing pockets of dairy goats (Alpine in western province and Saanen in eastern province) are another genetic resource worth to be preserved and improved through registration and selective breeding. These populations can start as register animals and through 3 generations develop into the Rwandan Alpine and the Rwandan Saanen goats, with their specific breed standard and minimum performance to be determined by the participating breeders/keepers. The NGOs working with these farmers can be instrumental in helping farmers, RAB and the National Animal Registration and Breeding Centre to develop the system of identification, registration and selection.

Activity 3.4.3 Form the National Animal Registration Centre for support and service provision to the individual flock/herd books and breeding groups

This centre will initially unite all the current data streams about animals coming into the MINAGRI and RAB and create the mechanisms to combine data to monitor and evaluate the impact of interventions (e.g. quality control of AI) and programmes (increasing milk production over years through use of AI, measured from performance testing of pedigree dairy cattle). It would be best placed within the Masaka Bull Centre, changing it into the National Animal Breeding and Registration Centre.
There will be need for hardware and the software required for pedigree and individual animals' performance recording, good internet access, connection to mobile (and fixed?) telephone networks and extensive training and TA to develop capacity and the system.

Some detailed budget elements:

Item	Units	Unit price	Total	Remarks
Community Livestock Breeding Groups	20?	5000	100.000	RAB to set target
Support to the emerging herd/flock books	5	10.000	50.000	Initially linked with National An. Breeding + Registration Centre
TA for NABRC	1 year	120.000	120.000	
National Animal Breeding and Registration Centre	1	50.000	50.000	Existing building Furniture, computers

3.5. Capacity building and participation

'Increase farmers' knowledge and understanding of genetic animal improvement and increase their role in the process

Activity	Budget (1000 USD)	2012	2013	2014	2015	2016	2017	2018	Stakeholders	Priority	Rwanda Contribution	Private sector Contribution	Partners in develop. Contribution
3.5.1 Develop a system of FFS's in the areas where MINAGRI/RAB/other organisations are currently working on genetic improvement	50 + recurrent	X	X	X	X	X	X	X	Consultant, RAB, farmer org.		Recurrent		50
3.5.2 Develop training and demonstration facilities for improved livestock production and management in the country	350 + recur.		X	X	X				RAB, district vets, MCCs		Recurrent		350
3.5.3 Perform a training needs' assessment among MINAGRI/RAB management and field staff and design training/exposure programme	100 + recur.	X	X	X	X				RAB, Research Pedigree farmers		Recurrent		100
3.5.4 Develop a farmer demonstration and training cycle and extension resources centre, in collaboration with private sector and NGOs	100		X	X	X	X	X	X	RAB, NGO's, research, farmers' organisations		50		50

Activity 3.5.1 Develop a system of FFS's in the areas where MINAGRI/RAB/other organisations are currently working on genetic improvement

The best assessment of suggested improvements is based on the farmers' own observations within the context of his own farm and possibilities and not on those generated in a livestock research station. The FFS extension concept puts the farmers in the driving seat of both adaptive research and extension. Combined with community animal breeding group activities this structure creates a way of doing selection within the population and to generate genetic improvement quickly without excessive costs and the deceptions of failure through e.g. imported animals' difficulties to adapt to local conditions. This activity will bring livestock selection and breeding on the doorstep of farmers and create an interest of in the future setting up or joining existing flock and herd books. FFS's offer researchers a chance together with farmers to engage in on farm trials under farmer management of new breeds, crosses and other livestock management practices. This activity has to be fitted into the on-going extension plans and activities.

Activity 3.5.2 Develop training and demonstration facilities for improved livestock production and management in the country

When people see something with their own eyes they can assess and accept it more easily. There do exist RAB facilities, in which this training and demonstration capacity can be incorporated at relatively low costs. There is already an organic training centre (GAKO) in Masaka, which can serve as an example how such a centre can be operated and serve various clients. Especially integrated poultry/pig/fish production needs more applied research and demonstration/training facilities. In chapter 2 is written what centres are needed:

- 3 demonstration and breeding apiaries near the major beekeeping zones
- 4 fish training and demonstration centres with teaching facilities (Musanze, Kigembe and 2 facilities on the livestock research centres Songa and Karama)
- 2 multipurpose and multi-species demonstration and training facilities in Eastern and Southern on the above mentioned livestock research centres

These centres should be equipped to show the latest technology and methodologies "real-time", preferably integrated in an overall farming operation of fodder production and integration with other livestock species in the case of fish. Where possible the exploitation and management of such units should be in private hands to create conditions to which farmers can relate, including farm records, of both production and finances. This can be achieved by e.g. selecting interested station workers and re-assigning them the task to run and develop such model production units within the research centre.

Activity 3.5.3 Perform a training needs' assessment among MINAGRI/RAB management and field staff and design training/exposure programme

After the restructuring of the various bodies of MINAGRI many people have been appointed in new positions, not necessarily with the right knowledge and experience to be fully confident and capable in the area they have been assigned to. Subject matter specialists from MINAGRI/RAB also need continuous updating and upgrading of their knowledge and skills to keep up with the latest developments. At the moment there is no structured plan for such upgrading. Such a training needs' assessment goes beyond the genetic improvement strategy and should be all-inclusive, best performed by an outside assessment and suggestions for a training plan. Trainers should be sourced from international organisations, visiting consultants should be asked to give guest lectures on their specific topic, general training on advanced use of computer programmes and IT facilities. Exposure visits in the region and to further away places should help Rwandan specialists to keep up with the developments in their specific fields.

Activity 3.5.4 Develop a farmer demonstration and training cycle and extension resources centre, in collaboration with private sector and NGOs

There are many organisations working in Rwanda that have and are conducting training and training materials in the area of livestock and agriculture. This experience gives an opportunity for the ministry and RAB to take advantage of the work done: document best and poor practices, analyse these organisations' training programmes and create continuity for and wider application of the better training programmes. Training materials can be collected and multiplied for wider use after checking and standardization.

The ministry of agriculture has recently opened its Agricultural Information and Communication Centre (AICC/CICA), adjacent to the ministry itself. This is a place, where livestock related extension materials should be collected and made available to the wider public after crosschecking and editing. RAB/AICC can make an inventory of existing training programmes of NGO's, evaluate and based on on-going FFSs and other developments and needs in the livestock sector design a national livestock training programme, in which NGOs and RAB work together to cover as many farmers as possible with the messages.

Specific budget elements:

Item	Units	Unit price	Total	Remarks
Bee Training Centres	3	50.000	150.000	In existing demonstration apiaries
Fish Training Centres	4	25.000	100.000	In existing Livestock Research Facilities
Multi-species livestock training/demo centres	2	100.000	200.000	Masaka and Songa Centre
TOTAL			**450.000**	

3.6. Conservation of animal genetic material

'Develop a sustainable programme for the genetic conservation of indigenous breeds of farm animals"

Activity	Budget (1000 USD)	2012	2013	2014	2015	2016	2017	2018	Stakeholders	Priority	Rwanda Contribution	Private sector Contribution	Partners in develop. Contribution
3.6.1 In collaboration with objective 3.1 update the inventory of indigenous species and their state in the country and identify which breeds will be included in the programme	75	X	X	X	X	X	X	X	RAB, Research and Universities, farmer org.	Medium	25+ Recurrent		50
3.6.2 Strengthen collaboration with organisations involved in the conservation of animal genetic resources (FAO and ILRI) and design joint programmes	50 + recur.		X	X	X				RAB, district vets, MCCs	Medium			50
3.6.3 Develop ways how indigenous species can be integrated with nature conservation and tourism to make the keeping of these in terms of production commercially less interesting animals more sustainable.	350		X	X	X				RAB, Min of Tourism, Research,	Low	25	100	225

Activity 3.6.1 In collaboration with objective 3.1 update the inventory of indigenous species and their state in the country and identify which breeds will be included in the programme

Except for the Inyambo and Ankole herds on the research stations there are no other clearly identified indigenous species that need protection. Contact should be sought with the FAO and ILRI to collaborate in this task. Better understanding of the current productive capacity of poultry, goats, sheep and pigs after the import of many animals from neighbouring countries after 1994 with returning refugees and crossing with imported exotic breeds will determine whether there are other animal "indigenous" genetic resources worth to be conserved.

Activity 3.6.2 Strengthen collaboration with organisations involved in the conservation of animal genetic resources (FAO and ILRI) and design joint programmes

Existing programmes for the study of indigenous genetic resources seem to end up in publications and not in actions. There is need to establish collaboration between the not yet existing herd books for Inyambo/Ankole in the various countries where this breed remains, in which FAO/ILRI could play a leading role and Rwanda an initiating role. A regional register for the breed including exchange of genetic material (which now happens at high political level on ad hoc basis) and a clear joint breeding strategy and breed standard would help to preserve the breed and improve its capacity for beef production.

Links with international organisations such as the World Watusi Organisation[20], the Ankole Watusi International Registry[21] or the European Association of Zoos and Aquaria with its breeding programme, including Watusi[22] could bring in commercial possibilities for the sale of genetic material (semen or embryos).

These activities will bring the keeping of Inyambo/Watusi/Inkuku to a higher plane and secure the breed's existence in the future.

Activity 3.6.3 Develop ways how indigenous species can be integrated with nature conservation and tourism to make the keeping of these in terms of production commercially less interesting animals more sustainable.

Rwanda's Akagera National Park has become increasingly smaller after 1994. In many countries a buffer zone is created around a park, in which restricted agriculture/livestock keeping can be practiced and in which people take advantage of the tourism by sharing in the revenues and selling products, arts and crafts to tourists. In Rwanda such a buffer zone could be where livestock and

[20] http://watusicattle.com/

[21] http://www.awir.org/

[22] http://www.eaza.net/activities/cp/Pages/EEPs.aspx

wildlife are integrated. In selective villages, strongly based on traditional design visitor centres could be provided where Rwandan food, based on local products can be sold. In this way the keeping of probably less productive indigenous animals (poultry, pigs, goats and sheep, Ankole/Inyambo) can be supplemented with tourism revenues, making the conservation of these breeds more sustainable. Examples are e.g. Hluhluwe national park in Swaziland, where Nguni cattle graze among the game animals and Amboseli in Kenya, where Maasai have access to the grazing in the park.
Such a programme should be worked out with the neighbouring ranchers to the ministry's livestock centre and the wildlife and tourism departments.

Some budget elements:

Item	Units	Unit price	Total	Remarks
Inventory and registration	lump sum		75.000	Part of 3.1.1
Study tours/seminars	Lump sum		75.000	
Consultancy eco/agro tourism	Lump sum		25.000	
Buffer zone developm.	Lump sum		200.000	
Infrastructure Visitor centre	Lump sum		100.000	
TOTAL			**475.000**	

4. Logical Framework

The genetic improvement of livestock in Rwanda

Continuous process, estimate for 1st of July 2012-1st of July 2019 (Consumables only for first year)

Project Intervention Model	Indicators	Means of verification	Critical assumptions
Overall objective: To contribute towards improving the efficiency/productivity of the animal resources subsector in a sustainable manner, promote public health and support marketing of both livestock and livestock products to contribute to the national efforts in poverty reduction, improved food security and income to the satisfaction of the expectations of key and subsidiary stakeholders	- Share of livestock within the overall agricultural GDP has increased - Availability of local products of animal origin in the country - % of rural households keeping livestock - Prevalence of zoonotic diseases	- Statistical Office - MINAGRI reports - MOH data on prevalence of zoonoses and food of animal origin borne diseases	Livestock development is approached in a holistic way, whereby animal health, nutrition and improvement are improved simultaneously for maximum impact
Project objective: To select and/or create the most suitable genetic material with which farmers will be able to achieve the highest returns from their livestock under the management and environmental conditions in place when the offspring of the animals in the genetic improvement programme start to produce	- Genetic improvement strategies and implementation plans part of overall master plans per animal species	- Updated master plans for milk, beef, poultry, fish, small ruminants and bee sectors	A high level of public-private collaboration to develop and implement such holistic master plans can be mobilized
Outputs: 1) Sound understanding of current productivity levels of animals achieved and a system to continuously monitor the impact of the genetic improvement on production under the improvement programmes put in place	Production level and calculated productivity Analysed data from milk factories, slaughter-houses and markets on totals and numbers produced and calculated productivity	Reports from districts and provincial MINAGRI offices Statistics from factories, markets, Dep. Of trade, Breed societies	Public and Private sector agree to cordially work together in collecting, analysing and publishing production and productivity data

2) A joint research and livestock development programme between MINAGRI, RAB and Agricultural universities, client oriented and solving pertinent problems and shortcomings in the livestock production systems, set up	Number of integrated client oriented research and development programmes established	- Joint Diagnostic Surveys - Joint Research Protocols - Joint Reports on results and recommendations	Institutes agree to pool resources and develop joint research and development programmes
3) Breeding systems based on clear breeding objectives, breed standards and a system of performance testing of animals set up	Breeding plans and livestock identification and registration systems for pedigree animals established	- Annual reports from RAB and National Animal Registration Office - Annual reports herd books	NABC manages to build a cordial public private collaborative framework
4) The right organizational frameworks at both national and village level for animal breeding have been set up and are operational	- The National Animal Breeding and Registration Centre (NABRC) operational - Number of community animal breeding groups	National Animal Breeding Centre gazette with decree Register of community animal breeding groups with NABC	Government officials accept the leading role farmers play in genetic improvement
5)People's knowledge and understanding of and their role in the process of genetic animal improvement have increased	Number of farmers actively participating in animal genetic improvement programmes	- Registration and annual report NABC	The extension services are effective in reaching the farmers with the genetic improvement plans
6) Develop a sustainable programme for the genetic conservation of indigenous breeds of farm animals	(Partially) self-financing schemes for the genetic conservation put in place	- RAB and NABC reports	

Activities:	**Inputs**	**Budgets**	
		1 857 250,00$	
Output 1 1.1 Baseline study on-farm production and current productivity 1.2 Registration and monitoring system of performance of the various animal species according to a predetermined method 1.3 Systematic recording and publishing/communication of the outcomes of performance recording, crossbreeding research and analyses	**A-Consultant Services** - Baseline study - IT support - Web site building and maintenance - A dairy manager for commercial farms - TA for setting up NABRC - Inventory and Registration for gen. conservation programme - Consultancy for eco/agro tourism dev.	**339 000,00 $** - 70 000,00 $ - 10 000,00 $ - 10.000,00 $ - 75. 000,00 $ - 120 000,00 $ - 50 000,00 $ - 24 000,00 $	
Output 2 2.1 Develop a research and development agenda per species in which genetic improvement is but one integrated aspect, to resolve the bottlenecks for improvement of productivity and production 2.2 Build up collaboration with the livestock keepers work through their own organisations to partake in animal husbandry and genetic improvement research 2.3 Create strong links to the extension services to identify pertinent problems and constraints, to field- test possible solutions, formulate extension messages and to communicate the outcome of the client oriented research through extension to farmers	**B- Works and Equipment** - Computer hardware NABRC - Animal I&R computer software - RFID implantable chips and readers Inyambo - Personal Digital Assistants - Printed cattle tags - Printed small ruminant tags - Application equipment - Import bulls and semen - Import boars, pig AI equipment and consumables - Import small ruminants for nuclei - Setting up 3 Bee Training Centres - Setting up 4 Fish Training Centres - Setting up multi-species demo/tr centres - Buffer zone development - Setting up visitor centre	**988 500,00 $- 1.038 500,00** - 20 000,00 $ - 50-100.000 $ - 5 000,00 $ - 40 000,00 $ - 40 000,00 $ - 3 500,00 $ - 10 000,00 $ - 45 000,00 $ - 25 000,00 $? - 150.000,00 $ - 100.000,00 $ - 200.000,00 $ - 200.000,00 $ - 100.000,00 $ -	
Output 3 3.1 Formulate for all animal species a breeding plan with the breeding genetic	**C- Training and meetings** - Formation 20 Comm. Livestock Br. Groups - Formation of herd and flock books	**300 000,00 $** - 100 000,00 $ - 50 000,00 $	

improvement objective, breed standard, registration requirements, in consultation and with agreement of the livestock owners involved in that breed and interested to participate 3.2 Expand the current animal identification and registration system and automate as much as possible the processes of data transfer 3.3 Build up and maintain a strategic stock of genetic material of the various species in the form of live animals, semen and possibly embryos 3.4 Set up a system of performance testing of individual pedigree animals, analyse data and provide feedback of the results to the livestock owners <u>Output 4</u> 4.1Establish livestock breeding groups at village level, feeding into objective 3.3 4.2 Promote the formation of registers, herd and flock books as private entities to maintain and improve existing and imported breeds of livestock 4.3 Form the National Animal Registration Centre for support and service provision to the individual flock/herd books and breeding groups <u>Output 5:</u> 5.1 Develop a system of FFS's in the areas where MINAGRI/RAB/other organisations are currently working on genetic improvement	- Study tours and seminars - Staff training **D- Programme Operations** - Printing - Livestock Research Bulletin - Staff MINAGRI, RAB, Universities - Communication **E-Unallocated (Contingency)**	- 50 000,00 $ - 100.000,00 $ **70 000,00 $** - 20.000,00 $ - 30 000,00 $ - Regular budget - 20 000,00 $ **159 750,00 $ (10% of above)**	

5.2 Develop training and demonstration facilities for improved livestock production and management in the country 5.3 Perform a training needs' assessment among MINAGRI/RAB management and field staff, design training and exposure programme 5.4 Develop a farmer demonstration and training cycle and extension resources centre, in collaboration with private sector and NGOs Output 6: 6.1 In collaboration with objective 1 update the inventory of indigenous species and their state in the country and identify which breeds will be included in the programme 6.2 Strengthen collaboration with organisations involved in the conservation of animal genetic resources (FAO and ILRI) and design joint programmes 6.3 Develop ways how indigenous species can be integrated with nature conservation and tourism to make the keeping of these in terms of production commercially less interesting animals more sustainable			

5. ANNEXES

5.1. Annex 2: People met

Key informants Apiculture

Name	Function	Organisation	Telephone	E-mail
Allsopp, Mike	Bee Researcher	Agric. Res. Council ARC	+27832885 059	AllsoppM@arc.agric.za
Boot, Willem Jan	Bee Researcher, Bee keeper	Wageningen University & Research		willemjan.boot@wur.nl
Calis, Johan	Bee Researcher, Bee Keeper	Wageningen University & Research		Johan.Calis@wur.nl
Mazimpaka, Eugene MAZIMPAKA	Beekeeping lecturer	Umutara Polytechnic University Nyagatare		e_mazimpaka@yahoo.com
MUKASEKURU, Mathilde	Professional in charge of Fish and Bees farming	MINAGRI Kigali	+25078865 4562	mahaut77@yahoo.fr
MUSHUMBA, Désiré	Beekeeping Programme Manager	ARDI Kigali	+25025257 45	mushdesire@yahoo.fr
NSABIMANA, Elie	Sen. Agribuss. Advisor	SNV Rwanda Kigali	+25078830 0315	ensabimana@snvworld.org
Wijk, Frits van	Retired Bee Expert (SNV)	PUM Netherlands		mirror@hetnet.nl
RUSHIGAJIKI, Didace	Professional in charge of Pigs and Poultry	MINAGRI Kigali	+25078866 6098	rushidida@yahoo.fr

Key informants Aquaculture

Name	**Function**	**Organisation**	**Telephone**	**E-mail**
MUKASEKURU, Mathilde	Professional in charge of Fish and Bees farming	MINAGRI Kigali	+25078865 4562	mahaut77@yahoo.fr
KAMUNDO, Stefanie	Professional in charge of fish farming	RAB Kigali		
RUTAGANIRA, Wilson	Coordinator	PAIGELAC		

Key informants Poultry

Habimana, Sylvain	Manager Rubirizi Hatch.	RAB	+2507889 09112	Shehab476@yahoo.fr
Heidloff, Paul	Poultry Consultant	Private	+1870966 4141	pheidloff@gmail.com

Mayigane, Landry	Inspector	RAB	+250788359212	mayigane@gmail.com
Ndayisenga, Fabrice	Director of Operations	APEL	_250785781138	fabiciosenga@yahoo.fr
Ruzibiza, Jean Claude	M. Director	Rwanda Best	+250788302406	rwandabest@rwandabest.com
Rutten, Ben	Advisor Pr. Sector Dev.	Royal Netherl. Embassy	_250783224083	Ben.rutten@minbuza.nl
Steel, Martin	Representative	VSF-Belgium	+250784836363	m.steel@vsf-belgium.org
Stenbock, Oleg	M. Director	Rwandachick	+2500788752131	ostenbock@hotmail.com
Ven, Paul van de	Area Manager Africa	ISA Hendrix genetics Nls	+31622809268	Paul.van.de.ven@hendrix-genetics.com

Key informants Rabbitry

Name	Function	Organisation	Telephone	E-mail
Ursula Uohle	Teacher	St. Lazar Mission School		ursula@uohly.de

Key informants pig production

Name	Function	Organisation	Telephone	E-mail
Akker, Willem van der	Pig farmer Netherlands	Private	+31622805928	Willem.van.den.Akker@hetnet.nl
Alst, G van	Export M.	Hypor Nld		Gerjan.van.Alst@hendrix-genetics.com
Kastler, Roland	Director	German Butchery	+250788300708	Rolandk43@yahoo.de
Anselme Papoke	Pig farmer/entrepreneur	German Butcher MTN centre	+25-788300707	
Frere Cyrille	Manager/Brother	CPPA Kisaro	Box 540 Kigali	wiemejules@yahoo.fr
Gerrits, Peter	Pig Expert	Hypor Nld		Peter.Gerrits@hendrix-genetics.com
Mukanyamibwa, Melanie	Pig expert/AI	CPPA Kisaro	+250783108125	melaniemuka@yahoo.fr
Kastler, Roland	Director	German Butchery	+250788300708	Rolandk43@yahoo.de
Mbarushimana	Pig farmer /leg. expert	Private/ government	+250788521479	Mbarusha2003@yahoo.fr

Key informants Small Ruminants

Name	**Function**	**Organisation**	**Telephone**	**E-mail**
Kagarama, George	Area Manager	Heifer Project Int.	+250788305016	
M. Manzi	Researcher	RAB		
Ndayisenga, Fabrice	Director of Operations	APEL programme	+25-785781138	fabriciosenga@yahoo.fr

Key informants Cattle

Name	Function	Organisation	Telephone	E-mail
Dotson, Brian	Director Pr.	Land O'Lakes	+254203748685	briandotson@idd.landolakes.com
Hagen, Lindsay	Consultant	EADD		lhagen@tns.org
Fukuyama, Megumi	ET expert	JICA-volunteers		Same-wish@hotmail.co.jp
Ingabire, Clarisse	Director Girinka	RAB		
Karamuzi, Dnnis	Country Pr. Manager	EADD	+250768305014	dkaramuzi@gmail.com
Kayisanabo, Fina	Agribus. Expert	USAID	+250788304369	
Kayumba, C.	Director	Heifer Int. Rwanda		
Klein Herenbrink, J.	Areamanager	CRV breeding NLd		
Masoni, Fidele	Res. Techn.	Songa Research St.		
Myambi Celestin	Division Leader	RAB Eastern Z.	+250788592297	cmyambi@gmail.com
Ndabikunze. M.	DG	RAB		
Nkurunziza, Chris	Head of Rubona St.	RAB		
Nshimiyimana, A.	Director Livestock	RAB		
Pandey, Rama K.	General Manager	Inyange Industries	+250788161901	
Semahoro, F.	Researcher	Songa Research St.		
Sinayobye, S	Acting DG	Savannah Dairy	+250788309056	Sava.dairy@yahoo.com
Steed, Annie	Agriculture officer	USAID	+250788385515	asteed@usaid.gov
Uimana, Gaspar	Head of Livestock	RAB Southern Z.		
Umuganwa, Josephine	Administrator	Heifer Interntional	+250788587119	josephineumuganwa@gmail.com

Others

Name	Function	Organisation	Telephone	E-mail
Backx, Frank	Advisor	Terrafina		
Beerling, Marie Louise	Sociologist, Consultant	Private		mlb@middel.com
Buregeya, Paulin	CEO	COPED Waste Collection	+250788301975	bpaulin@copedgroup.com
Gakwaya, John Paul	Man. Director	DIMPEX inter-national	+250788307519	mugabej@hotmail.com
Gashugi	Ass. Rep.	FAO	+25078830	Laurent.gashigu@fao.org

	Programme		4125	
Goldfarb, Jesse	Program Manager	One Acre Fund	+25078569 4472	Jesse.goldfarb@oneacrefund.org
Habimana, Anselme	Admin. Manager	Kabuye Sugar Works	+25078858 7987	habansel@yahoo.fr
Kanyandekwe, Christine	Deputy DG	RAB	+25078859 0435	K_chris2005@yahoo.fr
Krabbendam, Marcel	Counsellor	Royal Netherl. Embassy	+25078368 9975	Marcel.krabbendam@minbuza.nl
Matabishi, Dr. Innocent	Agribus. Advisor	SNV	+25078830 9056	jmatabishi@snvworld.org
Muia, Ndavi	Senior Bus. Manager EA	Technoserve	+25078830 1425	ndavi@tnsrwanda.org.rw
Munyerango, Richard	Managing Director	GAKO organic training centre	+25078830 6608	rmunyerango@yahoo.com
Mutalikanwa, Felicien	Chairman Board of D.	Minimex	+25078830 0240	f.mutalikanwa@minimex.sa.com
Ndabikunze, Martin Shem	DG	RAB	+25078838 9880	martinshem@yahoo.com
Niang, Papa	Consultant	Private	+22133820 6391	drniang@afriqueemergenceconseil.com
Rao, K. P.	Financial Controller	AZAM-Bakhresa	+25078838 1499	rao@bakhresa.com
Seck, Jactar	Consultant	Private	+22133820 6391	

5.2. Annex 3: Bibliography

Beekeeping

Minagri (2011-2012): Field report on "beekeeping activities", prepared by MUKASEKURU, Mathilde and RUSHIGAJIKI Didace

Minagri (2007): National beekeeping strategic plan document 2007-2012

GILLET, Didier (2011): Module sur les techniques modernes d'élevage des reines des abeilles (ARDI- Association Rwandaise pour la promotion du Développement Intégré

Laere, O. van (1969) : Bee rearing and selection in Belgium (Apiacta 2, 1969)

Aquaculture

Anon. (2004):GIFT Technology manual: an aid to Tilapia selective breeding (WorldFish Centre)

Arrignon, J.C.V. (1993): Tilapia (CTA/Macmillan Tropical agriculturalist series)

Rabbitry

Lukefahr S. D. and P. R. Cheeke (1990): Rabbit project planning strategies for developing countries (2) research applications (LRRD Vol 2 no 2: http://www.lrrd.org/lrrd2/3/cheeke2.htm)

Poultry

Heidloff P. (2012): Inception report poultry study MINAGRI

Kimani, T. and A. Nyarko (2011): Rwanda Poultry Value Chains, national and cross-border trade flows (FAO-ECTAD)

Lwesya, H., R K D Phoya, A C L Safalaoh and T N P Gondwe (2004): Rearing chicks in enclosures under village conditions: effect on chick growth and reproductive performance of mother hens (LRRD 16 (11) 2004) see internet

Ruana Mirindi Rwahama Kwetu (?): Etude d'elaboration du concept d'une filiere avicole rurale au sein dus PAPSTA, Rapport Final (MINAGRI)

pig production

Bister, J.L. (2010): Genetic improvement strategy of small stock (APEL, BTI)

Rushigajiki, D. and F. Nyirishema (2012): Report on pig industry base line study (Minagri)

www.topigs.com

Hypor-Hendrix Genetics

Small Ruminants

Sibomana, G.; Murayi, Th.; Sayers, A.R.; Wilson, R.T. (1989): Weight and weight gain of east African long-fat-tailed sheep on Rwanda research stations (ILCA)

Manzi, M. et al (2011): Phenotypic Characterization of Goats Raised under Traditional Husbandry Systems in Bugesera and Nyagatare Districts of Rwanda (ASCI)

Cattle

Muhuye, W.B. et al. (1999):Conservation and utilisation of the Sahiwal cattle in Kenya (KARI-AGRI)

Ndume, B.D. et al (2008): Genetic and morphological characterisation of the Ankole Longhorn cattlein the African Great Lakes region (EDP Sciences)

PADEBL (2009):Updating the master plan of the milk chain in Rwanda (Minagri)

SNV (2010): the Rwanda Dairy Sector Value Chain Analysis

USAID (2008): The tipping point: Positioning Rwanda's Dairy Industry for Local and Regional Competitiveness

5.3. Annex 4: Some additional information on genetic improvement in general and in Rwanda

Genetic improvement of animals in general

Farmers have over the centuries without current day's scientific genetic knowledge worked on the improvement of their animals. Most breeds currently in use in the world were not a result of work of scientists, but a result of practical farmers looking for those characteristics with which they expected and still expect to get the best results in terms of production and financial returns. There is purpose in any farmers' decisions on controlling the reproduction of his or her animals.

Modern day breeding programmes for livestock should have such a breeding purpose formulated. This creates the common understanding among the various stakeholders in the whole process on what the aim of the selective breeding is. A generic breeding purpose for livestock as per farmers' view is usually as follows:

> ***" Select those animals with which to produce the next generation, which farmers expect in the future to be able to generate the highest financial returns on investments ,resources and farmer labour."***

Also governments have their larger goals for the livestock sector as above described (key pillar for national economic growth and poverty eradication). The Rwandan government's larger goals for the livestock sector are contributing towards food security, especially in proteins, poverty alleviation at individual farmers' level and contribution towards general economic growth of the country.

With livestock in private hands, owned and managed by private farmers, animal breeding is a private good as in most countries of the world: farmers make and should continue to make the breeding decisions. The government can only use indirect ways and means to influence the breeding decisions of farmers to achieve its own wider goals for the livestock sector. These should be geared towards maximization of farmers' income by creating the right conditions in which livestock production is profitable, through which production and productivity increase become economically viable. The government is responsible to regulate and monitor the sector, create an enabling environment through fiscal policies, tariffs and import quota and through training, extension and research equip farmers with the necessary knowledge and skills to increase and improve production and productivity. In section 3 of this report these aspects will be further worked out as crosscutting issues, which have to support the farmers in increasing their production and income.

Once the breeding purpose has been determined we can go to work out how the genetic improvement can be achieved. In general what one sees in an animal in terms of appearance, behaviour and or production etc. is called the "phenotype". This is determined by a combination of an animal's genetic information and outside influences in terms of the effects of nutrition, disease challenges, climate etc., usually put under the umbrella "environment". This means that what an

animal eventually looks like, how it behaves and/or produces is a combination of two factors:

Phenotype = Genotype + Environment

The genotype refers to the genetic composition of an animal in terms of the genes governing that particular characteristic the animal possesses. The potential of an animal to express this genetic make-up depends to a large degree on a number of environmental conditions, such as feeding, disease control and general animal management. If these are not optimal an animal's production will not reach that genetic potential. The genetic potential of animals is already determined at the time of their birth, the likelihood that it will be expressed in actual production later on in life depends upon the way such an animal is raised and later fed and managed, in short the environment in which it grows up and later on must produce.

The genetic progress is the amount of improvement one can make in the genotype of animals. It depends upon a number of factors:

- ***Accuracy of selection (A):*** Depends on the degree of which variation found in the population for specific characteristics can be explained by genetic differences and not environmental ones. It is usually expressed as the hereditability (h^2).
- ***Intensity of selection (I)***: is a function of the SIZE of the PERFORMANCE TESTED population and the number of animals required to produce the next generation- the stricter one can select in a population the faster the genetic progress.
- ***Genetic variation (G)***: is a measure of how large the genetic variance for a characteristic in the population is: the larger the variation the more successful selection will be

The inheritable characteristics in an animal can be divided in 3 different categories:

- *morphological characteristics*: colour, pattern, size and adult weight. These are all easily seen and selected for and have a high hereditability.
- *physiological characteristics:* these determine how living beings and/or their organs function. Most production traits fall in this category and are usually complex, with many genes involved and a relatively low hereditability.
- *behavioural characteristics*: determining how organisms respond in a given situation. Usually such characteristics are fixed within a particular breed and have been selected over long periods, usually with a low hereditability. Examples are e.g. the different dog breeds but also level of aggressiveness in bees.

The genetic progress per generation is then a function of the three factors described above

Genetic progress =A x I x G

It is a combination of the hereditability (h^2), the intensity with which we can select and the size of the genetic variance for a characteristic in the population (in a very homogenous population in terms of genetic background this will be lower than in a heterogeneous population). When divided by the generation interval (GI, a weighted average factor for the four lines of selection (Sires to breed Sires, Dams to breed Dams, Sires to breed Dams and Dams to breed Sires) we get the formula for genetic progress per year:

Genetic progress per year = A x I x G/GI

Animal breeding consists of two consecutive actions:

- ***Select the best performing animals in terms of the defined breeding purpose, based on their genetic breeding value***
- ***Practice controlled reproduction to increase the frequency of the genes of these animals in the population.***

Formal animal breeding, other than farmers' selection criteria of breeding stock based on empirical and sometimes emotional factors (e.g. shape of horns in Inyambo!), depends on large populations of production controlled animals, individual animal identification and registration, a scientific background and analysis of the selection work and mechanisms to spread the selected superior genes widely in the population. Farmers have however over the centuries proven that their empirical methods are extremely effective: most existing livestock breeds are the work of farmers within their given environment selecting for the most suitable animals in terms of providing what the farmer needed, which is as much a breeding purpose as any scientifically formulated one.

Different breeding schemes:

Pure breeding

Most indigenous livestock breeds in Rwanda as in most other places have been developed over long periods by farmer selection without theoretical underpinning. In most cases this has resulted in animals, which are most likely the best adapted to the prevailing conditions, i.e. the environment in which they have to perform. Farmers select phenotypically and as everybody keeps the same breed the same characteristics are maintained within the population. To improve on traditional farmers' selection it is necessary to identify the superior animals, to know the genetic characteristics of the population and animals will have to be identified to facilitate effective performance recording on which the eventual selection will be based. There will have to be a sufficient proportion of animals present, which are performance tested to make a meaningful selection programme. There is need for a data collection and processing system and mechanisms to communicate the information back to farmers. This can be done in a formal way, but there is increasingly the realization that the traditional, informal way of performance testing and selection by farmers themselves could in some conditions be a better alternative than formal breeding schemes.

Pedigree breeding

This is a special way of pure breeding, whereby animals are recorded in a register with their ancestry. Only animals with 3 generations of also recorded ancestors are considered pedigree; before that stage has been reached animals complying with the breed standard can be recorded in a register as a precursor to pedigree registration.

Herd books, in which animals can be registered if they have 3 generations known parentage of pedigree or true to type register animals guarantee the genetic purity of an animal and thus the transmission of the characteristic trademarks of the breed concerned to the next generation. Such recording and registers do not exist in Rwanda and further in the report it will be assessed whether and if so how this can be achieved.

Cross breeding

Controlled crossbreeding is done according to a plan: which breed or line is the mother line and which one is the father line. For effective cross breeding pure parent (2 way cross) or sometimes grandparent lines (4 way cross) have to be maintained, with a selection programme for each of them to improve the genetics and maintain the specific traits of that line. Crossbreeding gives the so-called heterosis: hybrid vigor, whereby the offspring produces more than the average of the two parent breeds. After the first generation (F1) comes the question how to proceed, especially in terms of maintaining the heterosis' effects . There are various options:

- Make another cross with another purebred line (3-way cross) or another F1 from different lines (4-way cross). This is how pig and poultry grandparent and parent stock are used to produce the terminal cross (see further).
- Start selecting within the F1s and produce after a number of generations a stabilized new breed (offspring identical to parents): this is a long process, requiring large numbers of animals and money to run the programme. The heterosis effects will be lost and additive genetic effects will have to bring the genetic superiority of such a new synthetic breed. Experiences in East Africa have been mixed (e.g. the Mpwapwa in Tanzania and the Goma/Gishwati Sahiwal/Jersey/Ankole based breed have both disappeared), the South Africans got their Bonsmara and Drakensberger breed from such programme
- Terminal cross: the product of the cross becomes the end of the breeding programme- practiced in pig and poultry production, similar to e.g. hybrid maize production: terminal crosses usually carry maximum heterosis effects
- Criss-cross breeding or two breed rotation: the female crosses are bred back to the other breed than their sire. In this scheme 66% of the maximum heterosis is maintained per generation

'Random' breeding

Rwanda has imported a variety of genetic material over the last 15 years. This import of animals with perceived superior genetics from abroad into Rwanda for use in development programmes and distribution by government and other

structures to usually poor farmers has widened the gene-pool and increased the genetic variance considerably. In many cases it is questionable whether there are still purebred traditional breeds present (village chicken after large-scale bird distribution and cock exchange programmes, pigs with regular uncontrolled cross-breeding, rabbits and increasingly cattle). This system of breeding has created a gene pole with great variability and opportunities for farmer managed selection, usually for adaptability to local conditions. It offers opportunities for selection for increased productivity with improving conditions and quick genetic progress due to the high variability.

From the above can be concluded that Rwanda needs a plan to maintain and use its genetic resources. Import of genetic material should over time be gradually replaced by a system of local production of genetically superior animals for breeding purposes through in-country selection of genetically superior animals in the overall population. For this to happen, certain animal populations of superior genetic composition and characteristics will have to be identified, multiplied and used for future government and NGO's support programmes and be available for regular animal improvement activities.. It is likely that initially government and project support will be necessary to obtain and maintain the superior genetics. It is however critically important to if not first then at least simultaneously address the general management issues that hamper the expression of the genetic potential of animals already present in country.

Genetic improvement in Rwanda in particular

The first task for this assignment was to assess the current status of genetics and genetic improvement in Rwanda and use these for a 7[23] years' breeding strategy. With the above as the theoretical basis for this assignment the following points were key in determining the 7 years' breeding strategy:

- Identify those aspects of the national policies which have a direct bearing on the livestock sector (EDPRS, Vision 2020, PSTA II);
- Existing development strategies for livestock species already identified and implemented (the various strategy papers for beekeeping, fish, dairy master plan);
- Description of the various animal populations, in size, origin, location and genetic potential for as far known;
- A description of the various farming systems in which the animals are being kept as the principal determinants of production goals and conditions;
- Definition of the breeding purpose for the various animal species;
- An economic underpinning of the breeding strategies: a prediction what will be the economic benefit of genetic improvement and of improvements in the animals' environment in which they are required to produce;

[23]In livestock breeding a 7 year horizon is a bit arbitrary: this study aims at increasing the insight and assist government to make strategic decisions in the field of animal genetic improvement which will have a longer impact than 7 years.

- A plan how animal registration, performance testing, selection and controlled reproduction will be organized (the public-private partnership aspects);
- Improvements in productivity of animal through the improvement of the environmental factors are usually quicker and larger than those achieved through genetic improvement, especially when the environment is not optimal for high production. Genetic improvement should always go together with improvements of the general environment in which an animal has to show its productivity.

5.4. Annex 5: Animal husbandry and some production and economic parameters, important for genetic improvement

Introduction

Genetic improvement is done for and by farmers to earn more money with their animals. This can only be achieved when the production in itself is profitable and the general management and environment in which the animal lives are conducive for a high production. In many programmes genetic improvement attempts do not lead to any production increase, because either the farmer is not interested in that product as its production costs money instead of generating it, or the conditions under which the animal is asked to produce are unsuitable. It is important to have some basic data on the current level op productivity, description of the husbandry system and the organizational framework in which the production takes place. In genetic selection animals are ranked according to their production. This ranking might differ from one environment to another: the best animal less than one set of conditions is not necessarily the best under other conditions. This genetic-environmental interaction is usually a disturbing factor in genetic improvement, especially when this genetic improvement is based on imported genes, maybe belonging to the best production animals in the country of origin, however not necessarily the best in the recipient country. It needs therefore always to see genetic improvement in conjunction with the improvement of the general production environment. In the following some husbandry aspects and production and/or financial parameters will be discussed.

Beekeeping

The following figures are compiled from information received from various people during this mission.

Observations on general honey production:

Type of hive	Harvest short rain	Harvest long rain	Cost of hive (RWF)	% deserted/year
Traditional	2-3kg	4-5 kg	7000	40%
Kenya top bar	6-8 kg	10-15	16.000	2%
Langstroth	10-15	25-30	35.-60.000	1%

Price of honey
Farm gate 1500 RWF/kg, wholesale 2500/kg, after refining 3000 RWF/kg; retail 0.25kg 1250 RWF in jar (World market price Euro 2/kg (1500 RWF)

With genetic improvement usually not more than a few percent units per year the quickest increase in productivity and overall production can be achieved from husbandry practices and not from active genetic improvement programmes. The above table with productivity parameters shows the superiority of the Langstroth hive. It is uptake is however slow and the reason

for the reluctant uptake of Langstroth hives has to be investigated. It might well be a continuing need for training and support in operating these hives, from a technical but probably also financial point of view. It needs to be studied how these hives perform in the traditional setting. If the introduction of Langstroth hives on the ground requires the engagement of guards to protect these hives from predators and thieves, contrary to the hanging traditional hives with more aggressive bees, the profit might be lost already, because now the apiary needs 24 hours guarding. There is need for active training programmes of specialists and farmers to change farmers from honey harvesters into beekeepers.

Such training is best done on the job in an apiary. There are different options to achieve this. The setting up and maintenance of demonstration apiaries is expensive and running courses there also comes at a high cost. Nowadays most training programmes are developed in the form of Farmer Field Schools, whereby a group of farmers is facilitated by a master trainer to design together a study programme with issues chosen by and pertinent to the members of the group. After going through the whole cycle the most confident and experienced farmers can be engaged to become facilitators in other beekeeping FFS groups in the neighbourhood. In this way an autonomous research, learning and training system can be set up, which is cost effective, close to the beneficiaries and relevant for their own conditions.

ACTIONS:

- **study the uptake of Langstroth hives and determine the factors for success or failure of the change from traditional hives to Langstroth and production figures in comparison to traditional hives: kg honey, % absconded**
- **evaluate the on-going extension, training and demonstration programmes with LCBs and RAB specialists in terms of cost benefit and effectiveness and identify the strong points to be maintained of this programme**
- **develop 3 expert training centres for the training of a pool of master trainers in beekeeping and use these privately run centres for the multiplication of the superior colonies in that centre.**
- **start a system of FFS's in the beekeeping areas, using the cooperatives' or a particular farmer's apiary as the training centre/demonstration apiary and the above trained master trainers as the facilitators: increase the contact between RAB specialists and the beekeeping cooperatives.**
- **Evaluate the implementation of the 2007-2012 Strategy and prepare a 2012-2017 follow-up strategy, encompassing the above, the SNV managed multiple-year training programme and with a clear description of roles and responsibilities.**

Fish farming

Fish production in Rwanda is in its natural form as fishing in lakes and harvesting in fishponds. The former is strengthened by the reduction of predatory species and the introduction of *T. nilotica* from Lake Albert.
The changes set in motion in Lake management and promotion of aquaculture need strong support and facilitation from government side. Care should be taken that this emerging fish industry will become competitive and private sector driven. There is potential for Tilapia fillets to be exported to high-end markets, but this would require compliance with the demanding SPS requirements for such trade. This requires the building of a complete fish value chain, in which currently the cold chain, filleting plants complying with international (Codex Alimentarius) food safety standards and the trading channels are missing.

For the future three sources of fish are foreseen:

- controlled fishing in natural lakes;
- fish from aquaculture in ponds;
- cage culture in lakes and deep dams.

To achieve the development of fish farming into a viable business the developmental activities need to be geared towards the development of the value chain. At the moment many critical steps in the upstream part of the value chain are taken care of by the PAIGELAC project and might be in jeopardy (e.g. hatchery, transport fingerlings, financing of the sector) after this project ends.
There is need to promote and stimulate the entry of private entrepreneurs in the parts of the value chain now run by projects (the 3 fish hatcheries), strengthening of research (NUR's Rwasave centre) and in filling the missing links (cold chain, filleting and marketing). Tremendous training efforts are required to make the sector compliant with the SPS requirements.

Fish farming provides unique opportunities for the integration of livestock and crop production: fertilization of ponds with overhead housed pig/poultry/rabbits will recycle manure into fish, effluent from the fish ponds can be used to fertigate rice and crop fields. Fishponds can also be buffers of water for rice cultivation and play a role in the hydrology of the bottom wetlands developed for crop production. In a country with high land pressure this highly integrated form of agriculture and livestock production is appropriate and should be further developed and promoted. To put this system on a more scientifically sound basis (e.g. stocking rates of both fish and animals, feeding practices) there is need for research on these systems. Again the government livestock centres or centres for higher education are suitable to develop demonstration, training and research units. NUR has such facilities already in Rwasave but except for some rabbits these are not in use at the moment. Another 2 of such integrated livestock/crop production centres would have to be constructed to give more farmers a chance to be exposed to this technology.

The large increase in the number of fish ponds, integrated with rabbits (but could also be with pigs and/or poultry) gives another opportunity to develop a

poverty alleviation business model, utilizing livestock. As for most other livestock sectors it is important to think from a value chain perspective: the constant supply of quality fingerlings and feed, a cold chain and market should be assured for fish farming to be profitable and sustainable. If all fish ends up through informal ways in the city markets there is most likely going to be a saturation of those markets, leading to price erosion and this emerging industry might collapse. Concurrent with the increase in the hectarage of fishponds there should be market channel developments with diversification into fillet production and a search for outside markets. Only when these issues are resolved will fish farming be a profitable way for poor farmers to increase their income.

Table 18: Some parameters needed to calculate feed margin (many still unknown)

Fingerling cost price:??/piece		
Stocking rate	X/ha	Mortality rate till harvest? %
Time till harvesting:		
Fertilized pond		1 year? Weight: 800gr?
Pond with feeding		0.5 year? Wght 1000gr? F. Conversion 1.2?
Cost price fish feed? RWF		
Filleting yield		35-40%
Tilapia on Kigali markets		RWF 3000/kg
Wholesale Tilapia filet Kigali		RWF 4700/kg
Retail German Butchery Kigali		RWF 5500/kg
European supermarkets:		Euro 12/kg (frozen) to Euro 18/kg (chilled)

Rabbits

Rabbit farming in Rwanda is widespread. They can be kept by landless farmers and can be easily fed. Often with some minor additions the feeding can become more balanced. In most husbandry systems it is inappropriate housing and eventually lack of hygiene that after some time causes increased mortality and makes people to stop rabbit raising. The table hereunder gives a comparison between the production system as is and how it could be with improved breed and improved management. It is hard to separate the effect of the two on the production increase.

Rabbit meat in market Kigali RWF 2500/kg
Rabbit in villages RWF 1500-2000/kg
Prices of rabbit meat in restaurants comparable with chicken meat

Breed characteristic	**Current breed**	**Improved breed**
No of kidding /year	4-5 times	6-8 times
Av. No of kids/litter	5	8
Adult weight	1.5-2 kg	2.5-3 kg
Meat production	43.75 kg/doe year	154 kg/doe year

In Rwanda rabbits seem to be used in many development activities with a socio-economic character and poverty alleviation character, which can be seen when googling on "rabbits" and "Rwanda". There is little to no contact between such projects and MINAGRI/RAB. An informal group of rabbit husbandry practitioners would be a good tool to exchange experience and to learn from one another. Extension materials could be pooled, standardized and published in a standardized format. The RAB rabbit production officer is the indicated person to initiate such a group.

In a number of centrally situated places demonstration/training rabbit farms should be supported and developed. This can be in RAB's livestock research centres, integrated with fish and forage production, but also on missions and schools that have shown interest and capacity for rabbit production. These could also become the centres where improved genetic material will be kept, available for programmes and individual farmers for purchase. Rabbit production would fit well in a school agriculture programme and collaboration with the Ministry of Education for this could be instrumental in identifying suitable and interested schools.

ACTIONS:

- **Identify in key zones well performing rabbitries, which can be supported to become training, demonstration and genetic centres for rabbit production.**
- **Form a rabbit production platform with all the NGOs and organisations working in the promotion of rabbit production and through these develop jointly standardized extension materials and training programmes.**

- **Develop rabbit demonstration and breeding centres in the RAB livestock centres, where genetic material can be kept, multiplied and sold/distributed to interested parties.**

Poultry production

The Rwandan poultry sector can be roughly divided in the village poultry sector, semi-commercial and the commercial sector. The last one is small and a separate strategy is developed for this sector. The following table gives some production and financial figures to better understand what feed margins can be made in the semi-commercial and commercial poultry sectors if DOCs, appropriate feed and all veterinary requirements were available.

Broiler	DOC day 1	Feed 4kg (High cost	Feed 4kg (Low cost)	Various cost	Day 42		Low feed cost	High feed cost
		300/kg	200/kg		2kg life, 1.7 kg slaughtered		RWF/kg	RWF/kg
Cost (RWF):	750	1200	800	150	100	Cost price	1059	1294
						sold at	2300	2300
						Feed margin	1241	1006

Layers		**Production cycle**			**Total RWF**	
Point of lay	$7	72 weeks	400 eggs	egg price 55	22000	**Not included:**
Spent hen	$2.5	Feed: 500 days at 125gr		feed cost	-15625	*Vet cost*
		250/kg		Depreciation of Chicken	-2700	*Cost of Capital*
				Feed margin	3675	*Mortality*
						Depreciation

The village poultry sector usually suffers from high mortality of chicks during the first two months and both chicks and adult animals when there are disease outbreaks. Especially NDV can be a true killer; with the resulting purchase of replacement animals very often other diseases from other areas are brought in again.

It has been found that protecting the chicks the first month in a basket from predators and providing a small quantity of high quality feed increases their survival rate. They can be taken off the hen much earlier and the hen will start

laying earlier again. Promoting the basket rearing system, whereby chicks and mother hen are kept in isolation and given farm-mixed feed leads to a reduction in mortality with 50% and more[24]. In this way production and off-take can be increased tremendously at relatively low cost.

Poultry vaccination by veterinarians in the village setting is difficult: chicken are usually only confined in the evening, when veterinarians don't work. Instead of veterinarians it is better to start a programme to train village women poultry vaccinators, making use of the relatively new I-2 thermostable NVD vaccine to control the major poultry killer disease. The application with eye-drop as preferred pathway or even in feed or drinking water is simple and does not require much training.

The semi-commercial poultry sector produces for home consumption and partly for the market. This sector could increase its production of both eggs and meat and the profitability of their enterprise if they would make better use of their own grain resources in case of the slightly larger farmers with maize production. This can be achieved if there were poultry concentrate feeds available, providing all required protein, minerals and vitamins, which can be mixed with farmers' own grain. This would reduce feeding and transport costs. This type of farmers should also get access to the right type of poultry vaccines and drugs to keep their birds healthy. The combined effect of reduced mortality and increased productivity will lead to larger production and income.

The commercial poultry sector will only flourish when it organizes itself in farmers with parent stock to produce chicks, poultry rearers to produce point of lay chicken, broiler and layer keepers. For the sake of biosecurity and of specialization it will be better if one farm would only deal with one aspect of poultry production. Together with a commercial feed milling industry, producing above mentioned concentrates and for those without own grain complete balanced feed, which can provide advice besides its feed, the commercial poultry sector will take off. This subject is dealt with in detail in the commercial poultry development consultancy report and will not be further elaborated upon.

ACTIONS:

- **Develop innovative interventions in the village poultry sector through improved management (e.g. basket rearing of chicks or simple moveable coops) and increased and improved vaccination**
- **Develop the availability and use of concentrates in especially the semi-commercial poultry sector**
- **Assist the commercial poultry farmers to organize themselves in a more professional way, whereby there will be more specialization and collaboration between the various value chain stakeholders**

[24]Lwesya, H. et al (2004): Rearing chicks in enclosures under village conditions: effect on chick growth and reproductive performance of mother hens (LRRD 16 (11) 2004 http://www.lrrd.org/lrrd16/11/wesr16089.htm accessed 13-3-2012

Pig production

The following table gives a comparison between the productivity and returns in three different types of pig production to illustrate what the effect is of productivity, price of feed and most importantlyprice paid for the product.

Table 19: Number of pigs in Rwanda (*1000)

2005	2006	2007	2008	2009	2010
391	427	571	587	602	706

Source: RAB/Animal Resources Extension in Rwanda Statistical Yearbook 2011

Informal and formal value chains:

Traditional sow →	Traditional fattener →	Informal meat sale
2 farrowing/year 7 piglets	8-10 months on kitchen + grass	kg carcass at 2000/kg
Weaned 5kg @ 10.000 RWF	/crop waste 25 kg carcass @ 1000/kg	transp./slaughter 3000 each
Feed cost zero margin 50.000/sow	feed cost zero margin 15.000/fattener	margin/pig 22.000 each
Semi-intensive sow →	Semi-intensive fattener →	formal pork sector
2 farrowing/year 15 piglets	280kg feed @ 200 RWF/kg	deboning, cuts + processing
Weaned at 20kg @ 40.000 RWF	80kg carcass @ 1200	70kg @ 2500/kg mix price
Feed sow 800kg/y piglets 450kg	feed margin 0/fattener	transport/processing 10.000
Feed cost 1250*250 =312.500		margin/pig 69.000
Feed margin/sow 287.500		
Intensive sow (Europe) →	Intensive fattener →	Slaughterhouse /processor
2.4 farr./year 28 piglets	240kg feed @ 200 RWF/kg	70kg @ 3000/kg mix price
Weaned at 25kg @ 31500	85kg carcass @ 1125 RWF/kg	transport/processing 30.000
Feed sow 1100kg/y piglets 980/y	feed margin 16.125/fattener	margin/pig 84.375
Feedcost 2080*220= 457.600		

Source: discussions with various stakeholders in Rwanda and Netherlands

feed

The key issue lacking for profitable pig production in Rwanda is a reliable source of quality feeds at an accessible price level. This can be complete balanced feed or with the boom in locally produced maize in the form of a concentrate. Under the current practice with people buying each some individual ingredient it is unlikely that anybody manages to make a well balanced ration. The country has a number of mills/feed mills, but none of them is producing animal feed for various reasons of which one is they fear lack of clients due to the absence of a vibrant pig and poultry production sector: a typical catch 22.

The government could through concessional loans and guarantees entice the private sector, together with donor projects, to start up feed production, build up a distribution network and through availability of quality reasonably priced feed restore the profitability in the pig sector and improve the profitability in the poultry sector. This issue applies to fish and dairy cattle as well.

ACTIONS

- **Inventory of all major pig farms and farmers and animal numbers to be made (Minagri, RAB)**
- **Assessment of feed need for the existing pig production sector, based on above numbers (Minagri, NUR specialist)**

- **Strategic plan with the feed industry (see further) for start of manufacture: business plan and steps, access to strategic grain store of government, exemption for import of components and concessionary credit**

Slaughter, processing and retail:
These three are currently in the hand of a few companies that handle at least 2 if not 3 of these functions. For public health reasons slaughter and processing should be done in licensed premises, with adequate conditions, cool facilities and under veterinary supervision. This means that the country needs more registered abattoirs and processing facilities to be operated by private entrepreneurs. It is likely that the processing and retail, which currently are combined, will stay together and that with increasing production the main processors will be able to sell more product to other retailers.

ACTIONS:

- **Make an inventory of current slaughter and processing facilities in the country, capacity, state of affairs and throughput**
- **Based on the numbers and distribution of pigs from farm inventory and outcome of above slaughterhouse inventory determine the need for (mini) slaughter facilities and decide with branch organization where and how to establish: government owned with lease contract or privately owned, constructed with concessionary credit**
- **Put legislation in place to stop slaughter and processing of pigs outside licensed slaughterhouses and processing facilities**
-

Branch organization:
This is usually in the form of a pig industry board with representatives of all stakeholders. In an integrated value chain with various stakeholders agreements need to be reached on type of product, standards and prices. Such a body functions as the "value chain manager". Government can try to initiate such an initiative, but usually it is better to leave this to the private sector, ideally supported through a pig industry sector development project, which can finance the activities for some time, liaise with government and private sector and build up the value chain.
Such a board facilitates in establishing contracting arrangements between various value chain stakeholders, promoting in collaboration with government veterinary services public health issues (internal parasites such as Trichina, Ascaris, Taenia), quality control of stock feeds and could run a pig breeding and selection programme, including the registration and certification.

Small ruminants

As land resources are limited and the grazing areas are diminishing pasture areas livestock production in Rwanda has to intensify to make the best use of available fodder and feed resources. Another consultancy has extensively looked into the husbandry practices of small ruminants. It seems that there is a gradual shift away from tethering to zero grazing and cut and carry systems for feeding the goats. This means that animals can be more easily stall-fed in preparation for

slaughter. At the moment the marketing is fairly random on village and district markets, where consumers tend to buy directly. A more sophisticated value chain concept, with e.g. holding grounds and fattening near urban centres, a dedicated small ruminants' slaughtering slab would contribute towards higher goat and sheep meat consumption in the urban areas. Currently most goat meat is consumed in restaurants in the form of "brochettes".

ACTIONS:

- **Set up mechanisms to routinely collect data and generate information on small-ruminant production in the country, including genetic, financial, economic and managerial aspects**
- **Together with sheep and goat breeders/feeders improve the overall management, especially on the feeding of animals for the market**
- **Improve on the small-stock markets in the rural areas so that traders gain easier access**
- **Develop near cities holding grounds and simple small ruminant slaughtering slabs**

Cattle

The issues to be addressed have been spelled out earlier: health, feeding, general cow management and marketing issues. The overemphasis placed on milk production in Rwanda creates problems for farmers when there turns out to be no profitable market for it in the country. The (emerging) dairy farmers have need for a variety of services to support their milk and beef production. With the rapid installation of Milk Collection Centres (MMCs) the government is also creating a potentially powerful instrument to address a variety of needs cattle farmers have in terms of animal health care, breeding services, input supply and marketing. The following are a number of suggestions.

- A *veterinarian* could be attached to the MCC and be tasked with the general health care of the animals, both fulfilling the government mandate (e.g. compulsory vaccinations) and private mandate (e.g. treatments of individual animals). He/she will be the inseminator for the herd around the MCC: as such a person will build up a good personal relationship with farmers and live close to them it might be a way to increase the current low success rate of AI. He/she should also be made responsible for a national animal identification and registration system.
- For *improved feed availability* a MCC could function as the depot for and in-kind credit provider to farmers for concentrate feeds. The repayments can be deducted from the milk money. There is preliminary experience with this system in Rwanda and it has been successful in increasing productivity and production.
- *General cow management* has to be improved through training, extension and demonstrations. The same veterinarian, after being trained under a practical government cattle management programme in the right interventions for improved cattle production, runs the MCC's cattle management improvement programme. Ideally his/her training has made him/her into a master trainer, who can accompany the process of the formation of a FFS on keeping dairy cattle.

- *Marketing issues* are often beyond the control of an individual farmer, but through working as a group and with the production of high quality milk in a larger cooled quantity their bargaining power in the market place increases. For dairy plants such a development is one key to profitability on the input side through reduced spoilage, lower collection overheads and through better raw milk quality better products. This increased profitability for the dairy company should be shared with the farmers in a good value chain win-win modality.

Better developed economic models of cattle production and its profitability will show that the contribution from the sale of animals and beef is a considerable part of the overall returns from keeping cattle. If and when the dairy industry would start to calculate its overheads to collect milk in certain remote areas it might well be that the combination of these two calculations could change the government's policy and include the explicit production of meat from and with dairy cattle but also from specialized beef breeds within the cattle production strategies. Beef production would be most profitable in Eastern province, using an improved Inyambo/Ankole as the mother-line (good fertility and adaptability to local conditions) and a terminal sire (Boran, Simmental, Brahman, depending upon experience and farmers' preferences) to produce weaners for feedlotting. This would require the construction of a slaughterhouse in the region and the creation of a number of pedigree beef breed breeders to produce the bulls required for natural service, as commercial beef production based on AI is not viable.

A cattle identification and registration system would contribute towards better management of animals on farm, of animal movement, pedigree registration and AI quality control; if parentage will also be recorded the system could be used in future to issue pedigree certificates/cow passports to prove parentage. The veterinarian working at MCC level would be the right person to maintain this registration

Some cross-cutting animal husbandry issues

Common cross-sectorial issues for the livestock sector in Rwanda

Although considerable efforts have been and are being made by the government to modernize and transform the livestock sector into a market oriented sector producing safe quality products, which can even be exported there is a number of principal bottlenecks that keep the livestock sector behind:

- *The lack of animal feed*, both in quantitative and qualitative terms. For commercially oriented production systems using animals of high genetic potential, especially in dairy, poultry and pig production systems, balanced quality feed is a prerequisite to exploit this genetic potential of the animals. Currently every producer is his own feed producer, sourcing some ingredients but rarely capable and/or able to make a good balanced ration. In many cases the restricted availability and provision of water,

probably the cheapest feed element present, suppresses animal production.

- *Presence of animal diseases:* A number of (re) emerging diseases forms increasingly a bottleneck for production: in cattle new strains of FMD, Lumpy Skin Disease, small ruminants the threat of PPR, pig production ASF, poultry NVD and in bees Varroa.
- *poorly developed value chains*: most larger-scale producers besides producing feed are breeders, feeders, slaughterers and in some cases even retailers of their product. This means that nobody can concentrate on one aspect and production is sub-optimal.
- *ineffective or no organizational structures for the various sectors*, leading to missing out on opportunities to make use of economics of scale, lobbying for the sector and optimizing the sector's performance (discussed elsewhere in this report)
- *no designated places*, where intensive livestock production can be practiced: the current system of developing farms within the peri-urban zone leads with the inevitable growth of the city to complaints and future capital destruction when a farm has to move or closes down due to city development.
- *Limited demonstration and training facilities* for the livestock sector, where extension workers receive practical TOT training and farmers can come to see with their own eyes and for thematic hands-on courses. Suggestions are made elsewhere in this report how this issue can be overcome.
- *Environmental issues:* the livestock sector is often pointed out as a major contributor to erosion and climate change due to the emission of greenhouse gases.
- *Financing:* when talking about modernizing and improving the livestock production systems capital is required.

The lack of animal feed, both in quantitative and qualitative terms, is probably the biggest limiting factor for the development of the livestock sector in Rwanda. Although not part of the genetic strategy a few remarks need to be made about the importance of animal nutrition. For commercially oriented production systems using animals of high genetic potential, especially in dairy, poultry and pig production systems, balanced quality feed is a prerequisite to exploit this genetic potential of the animals. Currently every producer is his own feed producer, sourcing some ingredients but rarely capable and/or able to make a good balanced ration. In many cases the restricted availability and provision of water suppresses animal production. This is the cheapest "food stuff" and should be resolved before animals can make optimum use of improved feed, fodder and feeding.

There are 2 commercial feed mills in Rwanda (Huye, Rubirizi), which are either not in operation or used for milling maize for human consumption. An interesting alternative would be to explore the possibilities of utilizing Kibuye's sugar mill's bagasse as roughage base in a low-cost ruminant cube. This is only possible if they receive from an investment support industrial development programme support for a high-efficiency solid fuel burning system, which would use Kigali's city waste. It would be eligible for Kyoto and suitable to burn all sorts

of organic matter other than the bagasse, which is a crucial addition to the overall diet of ruminants with a shortage of overall feed. The sugar factory is burning around 20.000 tonnes of dry matter bagasse per year; this as 50% of a dairy meal would be the basis for 40.000 tonnes feed.

An enormous effort is needed to increase the quality and quantity of fodder and feed, for which research and development is needed: the available types of forages in the Karamu Centre are impressive, methods of their inclusion in the existing farming systems have to be developed (e.g. a 1-1-3 crop rotation of maize-soya-permanent pasture for hay making, inclusion of legumes in contours and terraces etc.). Also the use of leguminous trees for both animal and bee fodder can contribute towards more fodder and still produce timber.

Animal health is of great importance for animals to produce optimally. Genetic improvement will not bear fruit if diseases frequently attack animals, more productive animals are under stress and thus more prone to disease. It is therefore again one of the crosscutting issues to be taken care of in an overall livestock development strategy before one starts working on genetic improvement. There are emerging and re-emerging livestock diseases. Rwanda still has the occasional outbreaks of FMD and lumpy skin disease in cattle, for which preventive vaccination is required. Best would be a buffer zone vaccination along the borders through which the disease is known to enter, but his is costly. Existing worldwide TAD control programmes could support.
Peste de Petite Ruminants is a new disease for Rwanda and coming up from the north/Tanzania. The country should prepare a contingency plan for this disease. With a sero-surveillance system and the right diagnostic tests the situation should be monitored and an action plan should kick in when this disease has reached the country. Mortality in naïve animals is high as is abortion in the surviving animals.
Pigs continue to be attacked occasionally by African Swine Fever. Especially in the areas near forest reserves it is important to prevent contact between wild boar and domestic pigs. This can be done through a sanitary corridor without pigs and to put a restriction on free-range pig husbandry practices.

The above show that with all these risks nearby animal health assurance is due to its potential damage and losses of a higher priority than genetic improvement, which would be wiped out in the case of outbreaks with high mortality.

Markets and profitability : Farmers keep animals to make money. If farmers do not make money with their animals they will stop keeping those animals. Access to markets and price information and to have options where to sell are crucial in the farmers' search for profitability in livestock keeping.
Many of the livestock value-chains in Rwanda are still pristine and can improve considerably so that farmers can benefit from the economics of scale, improve their bargaining position and improve their animal management through training and advice. The formation of livestock keepers' groups, be it FFS's, community breeding groups, livestock keepers' associations/cooperatives or combinations of these form already one way to reach livestock keepers better and strengthen their business opportunities and skills. The MCCs play an important role in this respect as the binding factor between dairy farmers and

could form the entry point for private sector (dairy company, input suppliers, veterinarians) and government (public veterinarians, extension) to interact with the farmers. For all species-specific strategic development plans there should be a value chain analysis done with an economic analysis of actual and potential value addition. Only in this way a sustainable development of a sector can be guaranteed. Relatively new sectors (commercial dairy, commercial fish, commercial honey) are the most in need of such an approach as described elsewhere in this report.

Environmental care is an important aspect to be considered as it is integral part of the sustainability of a production system. The following gives an overview of the environmental issues per species.

Apiculture

Bees are important for the pollination of fruit and vegetable crops, which without bees will not produce or produce less. With the development of these sectors a new purpose for beekeepers will be created: pollination services. The current practice of mainly planting Eucalyptus should be reconsidered and can be enriched with bee friendly trees such as Acacia, Pseudorobinia. Also Caliandra and Leuceana (less desirable because of the presence of sucking Psyllids insects) produce honey and pollen, on which bees can live. There are currently areas where there is simply not sufficient nectar and pollen during the year for the bees under the current practice of harvesting all honey form a hive.

Fish farming

Excessive fertilization of ponds and/or heavy stocking rates with additional feeding will lead to enriched water, which could pollute rivers and other water ways, leading to eutrophication. The circulation water from fish ponds shall be led to rice and/or crop fields to avoid environmental pollution.
In the case of the start up of fileting there will be offal, which has to be disposed of in a responsible way. Drying and grinding into fishmeal, to be added to poultry or fish feed again, would be a suitable way to prevent this.

Rabbits

There are no environmental issues with rabbit production: the manure is either directly dropping into fishponds or collected and used in horticulture. The only issue might be when home tanning of skins takes place that the chemicals used are either disposed off in an acceptable way without contaminating water sources or recycled.

Poultry

There are no environmental issues in village poultry farming as manure is straight away used on the land. It might be that with increasing numbers of chicken farmers would have to confine them to stop chickens from destroying neighbours' gardens.
The commercial and semi-commercial sectors have to make sure that the litter of their stables is properly disposed off. Also the disposal of dead animals, especially considering the constant risk of HPAI and other poultry diseases has to be well regulated: large producers should have a closable pit and quick lime to cover bird carcasses and prevent predators and carrion eaters to take the carcasses away.

Pigs

Pigs have a name worldwide for being smelly and bother non-farming neighbours. There is need for setting aside areas where commercial pig producers can be assured that they can continue to produce their pigs. It is also important to develop protocols for the control and prevention of public health risks, related to the consumption of pork or contact with pigs. The pig production board should spearhead such programmes.

With large concentrations of pigs on farms where the available land area is restricted and feed is bought in the disposal of manure or slurry becomes a point of attention. Proper storage structures would be needed to avoid pollution of soil and waterways, whereby biogas production can assist in reducing the quantity and the amount of greenhouse gases emitted and improve the quality of the manure as fertilizer.

Small ruminants

Especially goats have a bad name in terms of promoting erosion. Although it is without doubt that their browsing behaviour could damage trees it should be said that usually goats are about the last animals that can still survive in a severely degraded environment and are then blamed for what humans, cattle and sheep started as they are the last to be seen when the signs of erosion become manifest. Goats can however be employed in bush control in a mixed grazing system with cattle. The major part of Rwandan goats are kept tethered or in zero-grazing conditions and as such do not pose a threat for the woody vegetation in the country.

Cattle

Uncontrolled cattle grazing causes erosion, especially near watering points and on the road from settlement to pastures. In Rwanda communal grazing is almost a thing of the past, in many areas animals can only be kept under a zero-grazing management system. The cut and carry system however relies on the vegetation growing along roads and in forest areas and in the long run could lead to impoverishment of the soils. Therefore own production of fodder should be promoted. Manure handling in many instances can and should be improved, especially considering the value Rwanda attaches to it for crop production. The manufacturing of biogas is an excellent contribution of cattle towards reducing the need for firewood for cooking and should be promoted. It also produces more effective manure after digestion, which is more efficient and less polluting.

Access to finance is important for the development of the livestock sector. Especially in a post-project or no project situation farmers should have the possibility to look for credit. In the following some suggestions per species are made on how this issue could be resolved.

Apiculture

Attempts at sector financing through the cooperatives seems to have been a failure due to poor financial management/at times fraud. Currently finance has been made available to the umbrella organisations to purchase honey, but without a clear market and price where this honey will be sold also this is bound to lead to deceptions. It seems that Rwandan beekeepers are traditional and

prefer to work on their own. For the development of innovative financial support models to modernize bee keeping promotion programmes should look for associations/cooperatives with a mixed male/female membership, including younger members. With an own contribution and peer pressure group loans can be made to such cooperatives/associations after the production of a business plan that clearly shows that there is a good chance for success to develop a viable activity with the money.

Fish farming

So far the sector has been financed by projects and NGOs. No sign of any business plan for hatcheries or ponds could be found, but would be necessary to establish whether fish farming pays off. One example to be studied is e.g. whether feeding is more profitable than producing fish in fertilized ponds and how much credit would be needed for farmers to be able to feed fish during the whole production cycle. Only with such data at hand the financial sector can be convinced to invest money into fish farmers or their cooperatives when want to invest in a cold chain or processing or expand their business etc. The businessmen taking over the hatcheries from the project financing will need sufficient working capital to continue to run the operations. These credits if required might need to be guaranteed. It is critically important to secure continuity, which at the moment is not yet the case.

Poultry

The 3 segments of the poultry sector have completely different financing needs:
The *village poultry farming sector* practices a low external input system, with hopefully an increasing output. Most of these poultry farmers have started with grants and donations of birds and equipment. “Pass on the gift” schemes with a small material input for the coop and feeders and drinkers would be a way to promote poultry production in the family sector. This becomes feasible when the semi-commercial sector is capable of producing the types of birds that can do well within the family-farming sector.
The semi-commercial poultry sector has modest financial requirements, especially at the start-up of a new batch investment capital is required. This sector should be able to lend from the local financial institutions with an interest in a rural loan portfolio. It should be considered whether through a guarantee fund managed by the poultry association access for farmers to such loans could be improved.
Commercial poultry production, including the feed milling, requires serious money for investment and the running costs. If the government is interested to build up rapidly a commercial poultry section it is not more logical that the government initially takes equity within the sector. Individual commercial poultry operators and feed millers could look for an association with a foreign company, interested in supplying premixes, parent stock or DOCs. For such combinations of partners there are matching grants available from various sources.

Rabbit production

Most financing in the rabbit sector is at the initial stage, which is usually picked up by the NGO promoting. APEL will finance the import of genetic material. As rabbit production is largely based on locally available low-cost materials there is little to no need for financing.

Pigs

Consultant has the impression that most people, who invest in pig production, are either businessmen or civil servants, who have the money to do so. These are "farmers with money", who as with some of the larger dairy cattle farm owners do not necessarily have to reach maximum results on their pig business. Sector financing could be developed in collaboration with the companies slaughtering and processing, who are responsible for the purchase of the pigs and which, together with the pig production board, could guarantee credits to developing pig farmers with a proven track record. Also financing through the feed industry is an option, whereby farmers get credits in kind for the period until slaughter.

In pig farming in peri-urban areas comes the additional issue of complaints of surrounding people about smell. It is hard for pig farmers to invest in improved stables etc. not knowing at what rate cities are growing. Designating areas for intensive livestock production (both poultry and pig) would alleviate this problem, although concentrating many animals in one area could also bring increased risk of animal diseases.

Small ruminants

The goat and sheep development sector has, looking at the results of a Google search on "goats" and "Rwanda", a wide range of financers in the form of NGOs and charitable organisations that help poor farmers, exists. It is not clear how these procure their animals, but it were better if through the above mentioned national platform such activities are more streamlined and supported by the government structures.
With better-developed marketing channels small and short-term goat feeding credits will assist farmers to gain maximum returns from their goats. The Umugede (sp) SACCO's could be involved as the financers of such credits.

Cattle

The most logical and probably sustainable focal point for service provision in future is the MCC. If the dairy sector would be profitable a MCC could recover the costs of this service provision from a margin on the milk. With feed at RWF 250 and farmers receiving 100-150 per litre there is little room for a MCC to provide services and recover the costs through withholding some of the milk money.

Currently a number of NGOs are running training and extension programmes, including the USAID funded dairy competitiveness programme. MINAGRI and RAB should make sure that these programmes fit into their overall strategy and plans with the sector. Therefore it is required that MINAGRI/RAB with the dairy board of Rwanda and major donors sit together to update the existing dairy development strategy and make sure that it states exactly who will do what so that it will be implemented.

Loans to farmers who want to improve their dairy production are at times made through the dairy plant, which guarantees the loan towards the financial institution. With the current financial situation of both the dairy plant and the farmers and the current economics of milk production in Rwanda this does not seem to be likely to happen any time soon.

5.5. Annex 6: Quick analysis of the implementation of the 2007-2012 beekeeping strategy

1) *Identification of beekeeping areas and beekeepers*: up to now not completed: there is no central overview of all beekeeping cooperatives, associations, HCCs, production figures etc. as nobody was indicated to do this job
2) *Production development*: RAB has in each zone an extension worker assigned to work in beekeeping, but not necessarily experienced himself, SNV contracts LCBs to work with the cooperatives, there is a beekeeping training centre with the NUR in the south, A recent survey executed by MINAGRI staff[25] shows a picture of cooperatives not well managed, mainly due to financial conflicts and dishonesty, members not selling through the cooperatives, lack of training and capable and knowledgeable extension workers, lack of interest on the side of livestock officers for beekeeping as part of their task and responsibility
3) *Capacity building*:
    b. *Organizing farmers in groups*: it seems that the cooperatives are registered, but so far have not been able to generate benefits to their members in the form of economics of scale in sale and procurement of equipment: most 'members' sell through their own channels for local brewing and consumption. Training in beekeeping centres and demonstration apiaries has not been the answer as it is difficult for farmers to come to a training course and costly for government to run such courses. Demonstration apiaries seem to have been initiated, but it is unclear to what extent these are used in the capacity building.
    c. *Beekeeping equipment supply*: modern Langstroth hives can only operate if beekeepers are trained and have the necessary equipment (smokers, veils, protective clothing). Reading the above cited report it seems that many Langstroth hives distributed by RAB have not taken into use as yet (as seen in 2 cooperatives' shops, where such hives were stored inside).
    d. *Honey Collection Centers*: a number has been formed, but due to a weak private sector in the honey trade (unwanted result of the long-time involvement of NGO's in the marketing?) it is hard to find a market outlet for honey for such centers.
    e. *Apex organizations and service providers*: attempts at establishing a national honey council like in Ethiopia, Kenya and Tanzania have so far failed and there is in actual matter of fact nobody operating as the national honey value chain manager.

[25] Mukasekuru, M., D. Rushigajiki (2012): Field Report on "beekeeping activities"

4) *market developments:*
    a. *market study:* although planned not executed
    b. *value addition:* seems to have been partly achieved, the envisaged loans to cooperatives through financial institutions has not and most improvements based on donor support
    c. *Branding and promotion:* Some cooperatives have developed their own brand, but there is no national Rwanda honey brand. Since 2009 export to the Middle-East, but without a national brand.
    d. *Quality standards:* it seems that RBS has set an "entrance standard", but it is doubtful whether the system put in place by RBS would be in compliance with the requirements of a potential EU export market or Fair Trade requirements. A strategic plan is required for this issue
    e. *Market orientation:* little was known in 2007 how the local market works and that is still the case. There is evidence of honey coming in from neighbouring countries as the local production, especially after the export to the Middle East started, is not sufficient and prices in surrounding countries are lower.
5) *policy development:*
    a. *a beekeeping law:* the current livestock and agriculture policies and laws do not have a beekeeping chapter. A concept was produced by SNV and submitted in 2010, which was used by MINAGRI and RAB to formulate a beekeeping law, which is in the process of being presented to Parliament.
    b. *Linkages with programmes and projects:* with the many organizations and institutions involved in the promotion of beekeeping and assisting beekeepers there is need for a beekeeping and honey platform, where sector issues are discussed, plans and resources shared and synergy created and overlap avoided. Such linkages have only partly been created, but not institutionalized.
6) *Monitoring and Evaluation*: in 2007 the sector was described as "information strapped" and still is. The wished for baseline survey to cover production, markets, socio-economic and environmental aspect as well as macro-level indicators did not take place.

Annex 7: Cost estimate for the running costs of a pig AI station with 10 boars

(with thanks to Peter Gerrits of TOPIGS the Netherlands for the information)

	10 boars		10 boars	
Description	**Quantity**	**Price per piece**	**Total amount**	**Can do without**
PROFESSIONAL MONO MICROSCOPE	1	€ 350.00	€ 350.00	
DIGITAL HEATED OBJECT STAGE	1	€ 225.00		€ 225.00
MEMMERT VACUUM OVEN UNE 500,	1	1,599.00		1,599.00
#MS SEMEN METER EXCL TESTKIT	1	€ 815.00	€ 815.00	
SET CALIBRATION CUVETTES FOR	1	€ 98.15	€ 98.15	
PACK OF 3 CUVETTES	1	€ 50.55	€ 50.55	
WARM WATERBATH, STAINL. STEEL	1	€ 725.00		€ 725.00
DEMINERALIZER 2000, COMPLETE	1	€ 375.00	€ 375.00	
MIXED BED RESIN 20 L FOR DEMI-	1	€ 160.00	€ 160.00	
CLIMATE CABINET 25LTR WITHDI	1	€ 100.00	€ 100.00	
BOAR MOUNT TILTNG MECHANISM	1	€ 432.00	€ 432.00	
PAIR OF FRONT FEET SUPPORTS	1	€ 23.95	€ 23.95	
RUBBER PIG MAT 100 X 100 CM	1	€ 49.46		€ 49.46
A.I. THERMOS FLASK	2	€ 9.96		€ 19.92
GRADUATED CYLINDER, 1000 ML	2	€ 15.50	€ 31.00	
SLIDE, PER 50 PIECES	10	€ 1.50	€ 15.00	
COVER-SLIP, PER 200 PIECES	4	€ 1.95	€ 7.80	
DISPOSABLE SEMEN COLLECTION	500	€ 0.09	€ 45.00	
ROUND MODEL FILTER GAUZE,	5	€ 8.99	€ 44.95	
BTS TOP 52.57 GRAMS	50	€ 1.40	€ 70.00	
VINYL GLOVE, SHORT, 100 PIECES	10	€ 5.50	€ 55.00	
MS SAFE FOAM CATH+CLOSING CAP	1	€ 75.00	€ 75.00	
BRUSH FOR FLASK, LENGTH 73 CM,	1	€ 5.23	€ 5.23	
DIGITAL SCALES UP TO 5,000 GR.	1	€ 56.72		€ 56.72
ELASTIC BANDS, BOX OF 500 GR.	1	€ 4.83	€ 4.83	
ERLENMEYER FLASK,3L,GLASS	2	€ 13.50	€ 27.00	
Total amount			**€ 2,785.46**	**€ 2,675.10**

Grey color: consumables for 10 boars per year.

Minimal equipment can probably be purchased in the country of destination far cheaper and in more suitable size than the articles in this sheet.

Construction of a small boar house with "biosecurity" will in practice mean, that the building is separated from other pig housing.
That entrance of this building is via showering room, and change of clothes and boots.
The laboratory must be physically separated from the boar house.
Hygiene in semen production is key.