

# **Global Agenda for Livestock Research**

## **Proceedings of the Consultation for the South-East Asia Region**

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Philippines

*edited by*

*C. Devendra and P. Gardiner*

**International Livestock Research  
Institute**

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# Preface

The Consultation reported here marks

...an historic event. For the first time in our history four Centres of the Consultative Group for International Agricultural Research (CGIAR) and 13 countries in South-East Asia are meeting to discuss priority areas and researchable issues in livestock production. In South-East Asia, livestock production is intimately linked to crop production. We cannot talk about livestock without relating it to feeds, crops and the environment.

Dr Bernardo, IRRI's Deputy Director General, in his opening address.

The impetus for this "historic event" was the formation of the International Livestock Research Institute (ILRI) which came into being on 1 January 1995, and is the newest of the agricultural research centres supported by the CGIAR. The institute was planned to be a new venture, capitalising on the major strengths in animal health and animal production research which, respectively had been pursued largely separately by the two previous livestock institutes, the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Centre for Africa (ILCA). ILCA and ILRAD had focused their research predominantly on Africa. ILRI, however, is charged with a global mandate. The strategic plans that underlie the foundation of ILRI name four principal research goals for the new centre. In addressing animal agriculture in developing regions, the institute's programmes were to aim to improve: (i) animal performance by overcoming identified constraints to animal productivity through technological research and conservation of genetic diversity amongst indigenous livestock populations; (ii) productivity of the major livestock and crop-livestock production systems typical of developing regions and to maintain, their long-term productivity; (iii) the technical and economic performance of the livestock sector in these regions to ensure the appropriate translation of production system improvement into increased food security and economic welfare; and (iv) the development, transfer and use of technology by national programmes and client farmers in the agricultural systems of these regions.

These goals will serve as the framework of the development of ILRI's new programme. They are applicable to the improvement of animal and agricultural productivity globally. However, the combination of biotechnological, adaptive, integrative and managerial solutions appropriate to the different problems, production systems and regions will differ. A commitment to globalising and integrating key aspects of research on livestock, largely through ecoregional initiatives and links to other programmes, is central to ILRI's strategy and to recommendations of other recent reviews of livestock in developing regions. Selection amongst priority problems and regions therefore is paramount in the efficient and effective use of CGIAR resources.

The Indicative Medium Term Plan for ILRI, developed in 1994, foresaw the need to establish a global agenda for livestock research through consultations with potential partners and clients in different developing country regions. The institute set aside some of its core funds for this purpose in 1995.

Part of ILRI's global mandate is to provide leadership in livestock agriculture on behalf of the CGIAR. The identification of an agreed global agenda for livestock research will support the development of appropriate research programmes by all those concerned with livestock improvement around the world. The Consultation

series does more than simply provide information for ILRI institutional planning purposes. It also helps establish links with partner organisations, identifies each institute's comparative advantage in addressing wider CGIAR initiatives in agriculture, and the way advice and assistance might best be formulated to aid the projects and programmes of other international and regional agencies. To start this process, ILRI held, at its headquarters in Nairobi, Kenya, a "global" Consultation in January 1995.

The Nairobi meeting drew together senior representatives of livestock research and development programmes in Asia, sub-Saharan Africa, North Africa and the Middle East, and Latin America and the Caribbean. These experts compared and contrasted general requirements for livestock research in these regions. The meeting gave ILRI the opportunity to present ILRI's global mandate against the background of recent CGIAR and other reviews and to introduce the regional consultation process which ILRI wished to develop. These first considerations of the requirements for livestock research in different regions concurred on the widespread importance of improving livestock feed resources and their utilisation. This will be the subject matter for a separate CGIAR System-wide Livestock Initiative (SLI).

Another initiative that is changing the fundamental approach of the international research centres is a move towards ecoregionality, i.e., considering, in a unified way, the agricultural requirements of areas linked by climate, geography, and other similar biophysical constraints. CGIAR centres have been given new responsibilities for developing coherent research programmes aiming to improve agriculture in the ecoregions in which they are situated. ILRI therefore formulated its consultation series within this ecoregional framework and has contacted both CGIAR and other centres resident in the regions to participate in the deliberations. ILRI plans to complete four regional consultations (two in Asia, one for the Latin America and Caribbean region and one for the West Asia and North African region). Because of the very large human and livestock populations in Asia and the close integration of many livestock species into the farming systems of the region, the planning documents for ILRI viewed Asia as the first major challenge for the institute. With its sister centre, the International Rice Research Institute (IRRI), which has the responsibility within the CGIAR for the humid/subhumid ecoregion of Asia, ILRI convened the present Consultation on livestock research needs for this region. The Consultation—hosted by IRRI at their headquarters in Los Banos, the Philippines—brought together representatives of national and international programmes for agriculture and livestock improvement with donors interested in the development of livestock and the broader South-East Asian region. The Consultation was able to capitalise on this accumulated regional knowledge. It helped to focus the requirements of livestock within the overall agricultural development framework, to define the priority production systems (often quite different from those in other continents), to examine the needs for livestock research, and to help the international institutes and their national programme partners define potential entry points for catalytic research on livestock.

The results of the Consultation can be seen through the collected papers and the active discussions which are included in edited versions. ILRI was pleased to receive much helpful advice from participants and their views and suggestions are reported here. These statements should be interpreted as advice and not yet the official programme of ILRI, as ILRI will follow through a series of regional consultations and planning meetings before deciding on how best to use its

international resources to tackle the priority research problems in partnership with organisations in the region.

The congenial atmosphere and wide-ranging discussions allowed the inclusion of impromptu talks, abbreviated transcripts of which have been added to the proceedings. The round-up discussions leading to the definition of a set of priority agro-ecological zones, their production systems and possible research thrusts to improve the contribution of livestock in these systems are summarised in the pages immediately following.

ILRI wishes to thank the directors and staff of IRRI for making this Consultation possible by providing the good will and encouragement, the scientific framework and the meeting venue. ILRI acknowledges with thanks additional financial support from the Australian Council for International Agricultural Research (ACIAR) for the staging of this important planning meeting and the opportunity to develop scientific and personal contacts with agricultural research representatives in the region. We are particularly grateful to all those who participated so generously with their time and commitment to ILRI's learning and planning processes.

We hope the proceedings will provide a tangible record of the success of the Consultation in pursuit of the aims of the CGIAR and its national partners in mounting integrated programmes of livestock and agricultural research for the humid and subhumid ecoregion of South-East Asia.

C. Devendra

P. Gardiner

# Summary report of the sub-regional discussion groups on livestock research priorities

## The ASEAN working group

Members of the group: T. Komiyama (Chairman), L. Cruz, C. Devendra (rapporteur), K. Diwyanto, A. Djajanegara, P. Faylon, R. Leng, T. Mukherjee, D. Roxas, M. Sasaki, S. Sarobal, C. Sevilla, W. Stur and M. Wanapat

The group covering the states of the Association of South East Asian Nations (ASEAN) had detailed discussions on defining the livestock priorities, research requirements, and ways to achieve these with a focus on Indonesia, Malaysia, the Philippines and Thailand. Discussions were conducted in three sequential phases.

In the first phase, each country identified the priority agro-ecological zones (AEZs) and, within each, priority production systems in which livestock research was required. The results are presented in Table 1. It was interesting that there was a consensual focus on the upland and lowland rainfed AEZs. Among the production systems, rice/buffalo and rice/cattle (beef and dairy), maize/buffalo and cattle systems, and the integration of ruminants with plantation crops (coconut, oil palm and rubber) were prominent.

Phase two focused on specific researchable areas within production systems and within each country. They are summarised in detail in the right hand column of Table 1. The most prominent priority research areas were feeding and nutrition, genetic improvement, methodologies for crop–animal interactions, and the promotion of the adoption of appropriate technologies.

Phase three discussed the research requirements within individual countries. Notwithstanding the variable research capacity in NARS and the availability of funds, the general consensus among the countries was a requirement for the following: adequate funding for livestock research, training, institutional strengthening, and germplasm conservation and use.

The group addressed the priorities among the common production systems which were established as:

- Rice/ruminants systems
- Tree crops/ruminants systems
- Integrated fish/livestock (ruminants and non-ruminants)/crops systems
- Field crops/ruminants systems (lowland rainfed and upland systems)

Of these, the integration of tree crops with ruminants was common to all countries, whereas rice/ruminants, fish/livestock/crop systems, and field crops/ruminants systems were common to two and to three countries.

Finally, discussion also focused on two related matters. One was linkages, information exchange and sharing and the other was ILRI's presence in Asia. On the first issue, the Philippine Carabao Centre (PCC) emphasised the need for closer co-operation and regional effort among countries and between regions, and indicated that PCC was ready to take this lead. Concerning ILRI's presence in Asia, there was a general consensus for an office to reflect commitment to the region, and undertake various Asian-led livestock activities.

**Table 1. Priority agro-ecological zone, production systems and researchable areas in the ASEAN countries.**

## The Indo-China working group

Members of the group: Vo-Tong Xuan (Chairman), M. Anders, B. Bouahom, G. Denning, P. Gardiner, H. Hayakawa, Le Than Hai, Liu Guodao, Douglas Little (rapporteur), A. Qureshi, D. Steane, S. Som and D. Thomas

Discussion began following collation of country responses to priority allocations for research in the format circulated during the meeting. From the responses and the discussion the individual country priorities by AEZ and production system were derived and are given Table 2. Setting of priorities among production systems was then undertaken, showing marked consensus in support of research on small holder crop/livestock systems in non-forested upland and lowland rainfed AEZs. Of importance, but considered a secondary priority, was research on extensive upland systems.

Production systems or individual component improvements of concern to specific countries are given in the right hand column of Table 2. Specific importance was accorded to: (a) the use of livestock to mitigate the effects of upland shifting cultivation systems (Laos), (b) animal health concerns (Cambodia) and, (c) intensive pig production in lowland rainfed areas (S. China and Vietnam). There was also evidence of substantial consensus in certain commodity and disciplinary requirements as follows:

- Integration of crop/livestock production systems was accorded highest priority
- Feed resources:
  1. Forage production including trees
  2. Crop residue and by product utilisation
  3. Feed conservation
  4. Formulation and application of supplementary feed block, e.g. urea/molasses
- Animal genetic resources:
  1. Breed improvement through exotic cross breeding
  2. Selection within indigenous breeds
- Animal health improvement:
  1. Improved disease diagnosis and treatment
  2. Vaccine production and delivery
  3. Evaluation of herbal treatment and traditional remedies
- Policy Analysis:
  - Credit, pricing and livestock regulation (quarantine)
  - Product quality control, environmental issues, and marketing

- Institutional strengthening:
- Training
- Networking
- Technology transfer
- Institution establishment (Cambodia)

The highest priorities amongst the above were given to forage and feed production, animal breed improvement, improved disease diagnosis and manpower development in the countries of Indo-China through training in livestock disciplines and integrated agricultural project management.

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**Table 2.** *Priority agro-ecological zone, production systems and researchable areas in the Indo-China countries.*

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# Welcoming remarks

*F.A. Bernardo*

Deputy Director General (International Services), International Rice Research  
Institute (IRRI), P.O. Box 933, Manila, the Philippines

Mr Assistant Secretary for Livestock of the Philippines, Dr Vo-Tong Xuan our member of the IRRI Board of Trustees, Dr Hank Fitzhugh, the Director General of ILRI, donor representatives, distinguished research administrators of different livestock research institutes and scientists of South-East Asia, warm welcome to Asia and the Philippines. Unfortunately, IRRI's new Director General, Dr Rothschild, is in Australia finishing a few things before completely devoting his time to IRRI. He sends his regrets for not being able to be with us this morning.

Today is an historic event. For the first time in our history, four international research centres of the CGIAR—ILRI, ICLARM, CIAT and IRRI—and 13 countries in South-East Asia are meeting to discuss priority areas and researchable issues in livestock production. In South-East Asia, livestock production is intimately linked to crop production. We cannot talk about livestock without relating it to feeds, crops and the environment.

This consultation is actually part of our commitment under the CGIAR system to develop an inter-centre collaborative research and development programme in the humid and semi-humid tropics of Asia, which is IRRI's responsibility. In this particular consultation, ILRI has taken the initiative as it is now mandated to develop a global research programme on livestock. Hopefully, participation of other international centres, as well as national agricultural systems (NARS), will help ILRI develop a relevant research programme, with major research thrusts that can help with the problems of South-East Asian countries.

Times have changed; we are now facing new challenges. With the approval and implementation of the General Agreement on Tariffs and Trade (GATT) each country will have to be more competitive. Each country must capitalise on its comparative economic advantage, and increase its efficiency in crop and livestock production. Each one will strive to increase productivity using the best available technologies and management systems.

The donor community is also changing. Most of our donors are now expecting us to give greater attention to conservation of natural resources, and environmental issues. Of course we in the CGIAR centres appreciate the importance of increasing food production, through improved technology, without overlooking sustainability issues. We must develop technologies that are technically feasible, environmentally safe, resource-use efficient, cost effective and profitable.

## **Need for collaboration in research and development**

World population is increasing by 90 million people every year. In Asia, the challenge of producing more food is complicated by limited arable land. In fact, in some countries land resources for food production have been decreasing due to rapid urbanisation and industrialisation.

There is no doubt that collaboration in research and development is the key to food security. Food security is not only a great challenge, but one which will continue and we can only solve it through co-operation. We cannot afford to work on this challenge in isolation. We can succeed in meeting it only if we work together.

Permit me to tell you a short story that illustrates a very important point concerning human nature and co-operation among people.

Once upon a time, there was a very religious man who realised he had only a few more days to live, yet he still wondered what the difference was between heaven and hell. One night he had a dream. In his dream, a prophet woke him up. The prophet spoke, "Come," he said "and I will show you what hell is." The man was taken to an old palace and into a big dining room. A hundred people were seated around a big table

with a huge bowl of stew right at the centre. Each person had a long spoon. There was chaos: each one was fighting for the food and spilling the stew on the floor, because it was difficult to use the long-handled spoon to feed oneself. Every time a person put the spoon in his mouth he hit the face of his neighbour with the very long handle. People were shouting and complaining about why each one was not given a small bowl and a short spoon. "Is this hell?" the man asked. "If this is not hell, what do you think this is?" the prophet replied. "There is plenty of food yet the people are hungry and fighting."

Then the prophet led the way, this time to show what heaven is. They went to another palace and entered a huge dining room. A hundred people were seated around a huge table with a very big bowl of stew right at the centre. Each person had a long spoon, but they were neither fighting nor complaining. In fact they were happily eating because with the very long spoon they were feeding one another. "Is this heaven?" the man asked. "Yes," the prophet replied. "Heaven and hell may be physically the same, but it's the people who make the difference."

This story emphasises the point that, in a community of people or nations facing a common problem, there may be order or chaos, co-operation or hostility, and success or failure, depending upon the attitude of people. It is our attitude towards each other that makes the difference.

Your presence here today signifies your deep appreciation of the importance of collaboration in the humid and subhumid tropics of Asia.

We hope everyone will participate actively in this important consultation. We also hope that your contributions to this consultation will enable ILRI, and all of us, to rightfully prioritise research problems in crop–livestock production in South-East Asia and identify areas of collaboration among international centres and national research programmes.

With your co-operation, and with the support of donors, we should not fail in our mission to help ensure food security in this part of the world.

# Introduction to the objectives of the meeting

*H.A. Fitzhugh*

Director General, International Livestock Research Institute (ILRI), P.O. Box  
30709, Nairobi, Kenya

Thank you Dr Bernardo.

Friends and colleagues, Mr Assistant Secretary, thank you for coming with us today to join in what we believe is an outstanding opportunity. We appreciate the opening remarks of Dr Bernardo who has set the stage very well for this opportunity, because here we will gather together those who are interested in agricultural research and the role of agricultural research in support of development. We look to agriculture to produce more food. In particular, we are interested in livestock and the role of livestock and crop–livestock systems, and we are interested in research that will support economic development as well as increase food production. We will talk about more of these details as we go through the proceedings over the next few days.

Before I talk to you a bit about the new International Livestock Research Institute (ILRI), I want to express our appreciation to the International Rice Research Institute (IRRI), the sister institute to ILRI and even though the names sound alike, do remember that these are sister institutes that are supported by the same group of donors. These donors and the institutes are concerned about increasing food production, and economic development for the benefit of people in this region. Rice is the most important crop in this region. As most of you know even better than we, livestock have an important, complementary role to play with rice in the improvement of food production and economic development. So it is fitting that whilst the title of this consultation is "Livestock research priorities in South-East Asia ", in fact the meeting is about crop–animal interaction. In this region particularly, as we talk about the importance of livestock research we will be focusing very much on livestock research as part of integrated crop–livestock systems.

For 20 years, the CGIAR has supported livestock research and this support came largely through the activities of two international livestock research institutes. One, the International Laboratory for Research on Animal Diseases (ILRAD) concentrated on two major diseases. As it happens, these two disease concerns have principal importance in Africa, but the more general issues associated with research on the two diseases have global application. The work of ILRAD was primarily laboratory-based, strategic research. The other institute, the International Livestock Centre for Africa (ILCA) focused its research on the constraints to livestock production—nutrition, genetics and the socio-economic constraints to livestock production—and, primarily followed an inter-disciplinary systems approach. Two years ago, the decision was made to join the resources of ILCA and ILRAD to form a single institute, the International Livestock Research Institute (ILRI), which has a global mandate.

Slightly more than two years ago I met with several of you at the AAAP [Asian Association for Animal Production] meeting in Bangkok and gave you an introduction to the possibility of the establishment of this new institute. You will remember at that time I suggested that there would be an opportunity for expanding research activities here in this region. I am therefore particularly pleased to be back

with you today so that we can talk more specifically about that opportunity. With a global mandate, ILRI's research will be focusing on improving animal performance through technological research with particular emphasis on animal genetic resources (David Steane and his colleagues in this region are developing a programme through FAO, again focused on animal genetic resources). We see the research of our institute, and the research of the institutes which many of you represent, supporting the conservation of animal genetic resources in this region. As I mentioned, the focus will be on livestock and crop–livestock systems. The focus will not only be on the technical aspects but also on the social and economic aspects with emphasis on development, transfer and utilisation of research-based technology by national programmes and client farmers. For ILRI as is true for most of your institutes, success will be measured only in terms of the movement of research-based technologies on to the farms. ILRI will be working with national and regional collaborators who will be responsible for moving the technology forward. This is another reason why we are not here to talk to you simply about what ILRI may do in this region, but to actually discuss how ILRI may be helpful to you as you prioritise, do the research and the extension to improve livestock production at the farm level.

ILRI's programme encompasses a very broad set of activities ranging from improvement of animal health, biodiversity of animal and forage genetic resources and support for livestock production. All of this is put together in a production systems approach. We have a major activity in the development of models and their use for production systems analyses and impact assessment. Increasingly, all of us are being asked to set our priorities in terms of how these will have social, economic or environmental impact. But this is what, we argue, are also the terms of the importance of the research, and how this research will actually have a noticeable effect at the farm level. Within the CGIAR there is a new word that has been coined, "ecoregional". This refers to regional priorities, such as within the South-East Asia region and others, where these regions are delineated by socio-economic and agro-ecological characteristics. So, in this region, the focus is primarily on the humid and subhumid agro-ecological zones and on the social and economic conditions of South-East Asia.

I think one of the particular economic characteristics in South-East Asia is that as economic development has moved very rapidly over the past decade, the demand for livestock products has increased very rapidly. So livestock increasingly provide a cash crop for the farmers in this region and livestock products are increasingly in demand by urban populations. Thus, ILRI will develop a substantial programme in livestock policy research, and this is presently co-ordinated with another sister centre, the International Food Policy Research Institute (IFPRI). We recognise that the principle constraints to livestock production are often not at the farm level, but they occur in terms of market development and support for infrastructure—whether it is roads to transport livestock and crop products, the processing facilities, foreign exchange policies, trade policies etc. If we are ready to provide a positive environment for the improvement of livestock production then there must be emphasis on the policy side.

ILRI's work on strengthening NARS is directed through training, information services and collaborative research networks. One of the questions we will be interested in through your responses is how ILRI may work in support of collaborative research networks in this region. There are already networks here so we want to find out if they need additional support and, if so, how ILRI might contribute.

As Dr Bernardo indicated, ILRI has the mandate for international livestock research. It is now the largest centre dealing with livestock research and I have described some of the activities that ILRI has under way. However, I wish to emphasise the other activities within the CGIAR, or that are supported by CGIAR, that deal with livestock. The International Centre for Tropical Agriculture (CIAT), which has its headquarters in Cali, Colombia, is working on forage genetics and the evaluation and utilisation of forage resources. In this region of South-East Asia, CIAT has a substantial regional programme. The International Centre for Agricultural Research in Dry Areas (ICARDA) has its headquarters in Aleppo, Syria. Livestock, especially small ruminants—sheep and goats—are particularly important in the West Asia and North Africa (WANA) region. ICARDA therefore has research activities that focus on small ruminant production systems in these dry areas. The International Centre for Research on Agroforestry (ICRAF) is also following an integrated approach to those systems in which trees and shrubs, along with crops or livestock are often important. ICRAF too has a small but an important component of livestock research. At this particular time and over the last year or so, the CGIAR centres have been developing a new set of programmes in the various regions. These are referred to as ecoregional initiatives which are supported by a research consortium that includes national and international centres working together. We believe one of the particular opportunities in South-East Asia will be for livestock research supported through, and undertaken by, this consortium.

Finally, there is a substantially new initiative that is supported by the CGIAR that is referred to as the System-wide Livestock Initiative (SLI). There is a real opportunity in this region for financial support through this initiative for research focusing on livestock feed resources and related research.

There are many ecoregional initiatives that are now being developed by the CGIAR in collaboration with NARS in many regions of the world. In Asia, there are two major convening centres. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which is focusing on the arid and semi-arid tropics of South Asia, and IRRI, working in the humid and subhumid regions of South-East Asia. There are several different consortia that Dr Bernardo and his colleagues here at IRRI are working with. There is an opportunity to expand the role of livestock research in these consortia. There is also opportunity to develop new resources. By the time we have moved through the next four days of discussion we hope that we will have identified these opportunities as to how we might work together, either through existing consortia or, if there is need, to develop others. I have mentioned that CIAT is working in this region and, along with IRRI, is focusing on forage development in South-East Asia.

I want to illustrate a very important distinction between what I have just said about the System-wide Livestock Initiative (SLI) and the System-wide Livestock Programme. The latter refers to all the activities supported by the CGIAR and its partners who deal with livestock. What we are putting together in this basket is the entire set of activities. These include the core activities of the different international centres that I have referred to, i.e. CIAT, ICRAF, ICARDA etc.

ILRI brings together resources focused previously on Africa but now has a global mandate. We decided that in order to expand activities in Asia and Latin America and the Caribbean (LAC) we should consult the true experts of livestock research, who are located in these regions. So we are here to meet with you to determine what the priorities are for livestock research in South-East Asia. During the course

of the year we will be attending other consultations similar to this: one in South Asia, one in the Mediterranean or WANA region and one in LAC. In each of these regions, we will meet with the leaders of livestock research and the leaders of institutions that will utilise the research to determine with them what the priorities will be. These priorities are not just what ILRI will do. In fact, ILRI will always be a relatively small contributor within each of these regions because the major contributions will come from the national and regional research institutes. These institutes are where the greatest number of scientists and resources are and, appropriately, are closest to the farmers to whom the benefit of research will later be transferred. The agenda for research will be the one that we agree on for all of the livestock research institutes in the regions, including the universities. We believe that the opportunities for ILRI as an international livestock institute will revolve around these priorities and the appropriate roles for the different institutes. We hope that by the end of this year, particularly in Asia where we are giving primary emphasis for the first year, we will have identified what role ILRI can play, so that over the next few years livestock research will become even more effective and productive.

We are here quite specifically today to talk to you about the priorities for livestock research, to learn what you are doing and, from that, to identify together what contribution ILRI may make. Our first objective would be to establish the agenda for livestock research in South-East Asia and then identify the contributions that you see ILRI making. A second activity will be to identify opportunities for support from the SLI which has available to it annual funding of US\$ 4 million. The support will be allocated to consortia of national and international research institutes who are interested in working together on research problems of both the global and ecoregional nature. Emphasis on this research will be on the production and utilisation of feed resources. This will be for agricultural systems in which livestock are important or in which the value of livestock can be increased by the improvement of production and feed. There will also be emphasis on natural resource management, soil, water animal and plant genetic resources as they affect utilisation of these feeds in the systems. Funding will be allocated to multiple partners or to consortia of multiple partners including the CG centres (such as IRRI, ICRISAT and the International Centre for Living Aquatic Resource Management (ICLARM)) which are working in this region, with CIAT, national research institutes (including universities) and advanced institutes.

ILRI serves as a convening centre but does not necessarily have to be a member of the consortia. If it is appropriate we are more than interested in joining with you, but it is not a condition for receiving grants. The research will be strategic and applied in nature, and we would anticipate that different members of the consortia would take responsibility for different types of research. Perhaps the international centres would focus more on the strategic and applied aspects, while the national centres would focus more on being sure that the work will fit the needs of farmers in the region. We will be seeking opportunities for linkages between the results coming out of different regions, because this will be one of the ways to promote transfer of these research-based technologies between developing regions.

You may be interested in hearing of the progress with the consortia that ILRI is responsible for. Last week (2–4 May) we had a meeting in Nairobi in which the representatives from the convening CG centres in the various regions came together, and we developed the guidelines for writing the proposals, and the basis for which funding allocations will be made. Because these will be on a competitive grant basis, it is the quality of the proposals that will determine which ones to fund.

During the course of this consultation we may have the opportunity to discuss more with you about the SLI. In particular, I would like to recognise Dr Derrick Thomas who is working with us to develop the specifics of the SLI. As questions come up you can raise them with me or Dr Thomas. I would also like to introduce Dr Komiyama who is a member of the ILRI Board of Trustees. Dr Komiyama is representing the ILRI Board at this consultation. Dr Peter Gardiner is organising the Global Agenda for Livestock Research (GALR), so he is responsible for all these meetings that we are having around the world during the course of this year. A person that I do not have to introduce to this group but I do want to recognise, is Dr C. Devendra, because he is the person who has in fact served as an experienced and very knowledgeable livestock specialist for this region. Dr Devendra is working as a senior associate for ILRI and is guiding the development of the livestock research agenda in Asia.

With that let me stop. Thank you again for the opportunity to be here. We look forward to meeting with you over the next four days and determining how research can improve the productivity of livestock research in South-East Asia.

# **Globalising sustainable livestock production through research and technology: Addressing the needs of the 21st century**

*R. Nazareno*

Assistant Secretary, Department of Agriculture, Diliman, Quezon City, the Philippines

## **Introduction**

My fellow "aggie" and co-alumnus, Dr Hank Fitzhugh, Dr Bernardo, distinguished scientists and researchers, gentlemen, good morning.

On behalf of our people and government, I welcome you all to the Philippines. I thank you for choosing our nation as the site for the South-East Asia consultation on livestock.

I especially would like to commend ILRI for holding this very important consultation among South-East Asian nations. Your commitment to the upgrading and globalisation of technology and research in livestock is indeed a necessary dimension of our strategy to achieve global competitiveness and self-sufficiency in agriculture.

Your agenda today is crucial to the future of livestock in the world market. Given the competition and the challenges that agriculture, in particular livestock, faces it is imperative that we equip ourselves with the tools needed to catch up with the burgeoning demands of a growing population.

We in South-East Asia believe that we can become competitive in the livestock industry given the requisite technologies and expertise demanded to raise and sustain livestock production and ensure its excellent quality.

As you carry on the task of enlightening our fellow participants to the progress and developments that your institution has achieved in livestock technology and research, we anticipate that through this consultation we will be able to deal more efficiently with the various problems that encumber the growth of our livestock industry.

## **The challenges for South-East Asian agriculture in GATT**

The challenge of sustainable growth and agriculture is felt deeper in the heart of Asia. According to studies, Asia accounts for 75% of the worlds' agricultural population. It is the biggest and most expansive food producing region in the world, and yet only 21% of Asia's total land area is dedicated to agriculture. The paradox is that Asia, despite its significant role as the world's biggest agricultural workhorse, is less productive than our counterparts from the western world.

In livestock, for instance, production of meat and dairy products have yet to reach the same production volume as our Western counterparts. In 1994, there were 1.3 billion cattle, 149 million buffaloes, 873 million hogs and some 12 billion head of poultry in the world. Of the cattle population only 32% were found in the Asian

region contributing 16% of the total meat production and 15% of cow milk production.

Despite the lopsided percentages in contributions, South-East Asia continues to increase its production levels and thus contribute to the strengthening of its economy. Our region is currently experiencing an upswing in the economy maintaining a 4.3–8.9% increase in gross domestic product. However, the pressure to effectively compete in the international trading arena is felt even more with the advent of the General Agreement on Tariff and Trade, Uruguay Round. While our membership in the World Trade Organisation (WTO) has indeed widened the horizon for the South-East Asian market, it also forces us to produce products that are competitive globally. Our challenge is to meet those standards set by the WTO and make South-East Asian agricultural production efficient and dynamic in order to sustain the gains that we have painstakingly built during the past decades.

## **Technology and research: Maintaining an edge in global competitiveness**

For us in agriculture, global competition in the face of the Uruguay Round of GATT necessitates that we come up with better quality and bigger volumes of agricultural products. It is therefore imperative that technology and research be tapped to their fullest to address the challenge the global of competition. Increased productivity, the best use of our lands, ecological-preserving measures and the unified agricultural policy agenda are essential components in developing a strategic plan of action towards global competitiveness and agricultural sustainability. Today's consultation will hopefully provide substantial information and amplification on these components.

Another aspect that we must look into is the method of livestock farming. The Asian livestock scene is currently dominated by smallholder farmers. But even among them, changes in production systems, in orientation, and technology adoption will be instituted. There is also a need to consider long-term requirements of production, like producing breeder stocks endowed with higher genetic potentials. These challenges and needs in the development of livestock in world agriculture are strengthened through the research and technologies developed by institutions like ILRI and the CGIAR. As such, our quest for self-sufficiency and a sustained growth in the countryside into the next century and beyond are steadily becoming a reality. What needs to be done is to refocus these technologies and research into viable and workable solutions indigenous to the lands and resources of our people. Increased productivity can be derived by adopting new technologies for livestock production with indigenous technologies derived from local agricultural technologies and practices and integrating them into efficient production systems typical of South-East Asian nations. This is the challenge that our scientists and agricultural workers face today.

## **Medium Term Agricultural Development Plan: The Philippine experience**

For us here in the Philippines, the development of the livestock industry is an important component of our Medium Term Agricultural Development Plan (MTLDP). MTLDP identifies Key Livestock Development Areas (KLDAs) where livestock are most appropriate considering feeds, climate, infrastructure,

sociocultural and even political aspects. In short, it means raising the right livestock at the right place and at the right time.

In these KLDAs, government support services are prioritised. It seeks to lay the foundation for a more productive, efficient and sustainable livestock industry. Our aim is to increase the number of livestock nation-wide and improve the productivity levels and genetic character of the national herds. At present, we are implementing the MTLDP in identifying KLDAs nation-wide. We have prioritised our resources to improve our infrastructure, technology and research, and credit as well as implementing agricultural policies and laws that will sustain the gains that we have made since the inception of the programme.

## **Closing remarks**

Ladies and gentlemen, the challenge of making agriculture a viable and profitable enterprise for our nation is inevitable with or without the Uruguay Round of GATT. Times require that we must increase our productivity to sufficiently address the needs of a growing population. We in the agricultural sector must bond together to face a formidable task: that of making agriculture a sustainable endeavour in order that we may continue to feed the world and sustain the future generations of this earth.

# Research and development for forage production and supply in South-East Asia

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## Abstract

Research and development of forage production and supply in South-East Asia is described with reference to CIAT's regional programme. Examples of situations where planted forage can be useful to ruminants are grasslands, intensive livestock-based systems, tree plantations and other agroforestry systems, lowland rice cropping systems, upland rice and other upland systems. The objectives, target agro-ecosystems, mode of operation and of activities of the Forages for Smallholders Project for the period 1995–99 are described.

## Introduction

### The need for forages—10 years ago

In 1985, the Australian Centre for International Agricultural Research (ACIAR) sponsored a workshop entitled "Forages in Southeast Asian and South Pacific Agriculture". Remenyi and McWilliam (1986) presented a paper on "Ruminant production trends in Southeast Asia and the South Pacific, and the need for forages", which analysed trends in the demand for meat, ruminant production and forage supply. The authors projected, that:

- despite increases in livestock production, demand for meat will outstrip production, reducing the level of self-sufficiency in meat production in the region from 94% in 1973–77 to 62% in the year 2000
- projected increases in ruminant production will double the demand for forages resources by the year 2000.

### The need for forages—the situation today

The predictions made by Remenyi and McWilliam (1986) have largely come true. Increasing demand for meat has outstripped production resulting in higher prices for livestock products in many countries in the region. The need for higher ruminant production has been recognised by governments and international agencies, and programmes promoting large and small ruminant production have been initiated in many countries. Indeed, higher livestock prices have led to considerable interest by farmers in expanding ruminant production. Ruminant populations are increasing in many countries, while the availability of feed resources has essentially remained constant. Consequently, naturally-occurring forages in cropping areas are fully utilised and additional ruminant production has been extended into less favourable fragile environments. There are now few areas in South-East Asia where there are naturally-occurring forages which are not fully used for ruminant production, and the main limitation to further increases in ruminant production in the region is the lack, and poor quality, of feed.

## Feed resources

Ruminants are fed predominantly on naturally-occurring forages (e.g. grasses and leaves) in areas which are not occupied by crops, crop residues and agricultural by-products, and in some areas on planted forages (grasses, tree legumes and other legumes). This paper concentrates on aspects relating to naturally-occurring and planted forages.

## Opportunities for increasing forage production in agro-ecosystems in South-East Asia

Planted forages have the potential to substantially increase the amount and quality of forage supply and so supplement low quality naturally occurring forages and crop residues. The following are some examples from different agro-ecosystems in South-East Asia of how planted forages can contribute to the development of productive and sustainable ruminant production systems.

### Extensive livestock-based farming systems (grasslands)

Natural grasslands often occur in areas with a long dry season and soils of low fertility. In South-East Asia there are only relatively small areas of natural grasslands.

Forage opportunities are limited because of environmental conditions limiting forage productivity. Often, natural grasslands are used for cattle breeding, supplying cattle for intensive fattening systems close to the market. For example, feeder cattle for fattening in Batangas, the Philippines, are either imported or come from extensive livestock production areas such as the island of Masbate. In Batangas the cattle are fattened on crop by-products such as sugar-cane.

In Amarasi, Timor, Indonesia (extensive natural grasslands), planted forages are used for fattening purposes to provide high liveweight gains. *Leucaena leucocephala* and other tree legumes are grown and the leaves from these trees, plus banana stems, are used for cattle fattening with liveweight gains of 0.5 kg/head per day (Barlow et al 1990). This is a substantial increase from the approximately 0.2 kg/head per day achievable on naturally-occurring forages in that area.

### Intensive livestock-based systems

These include dairy farms and cattle feedlots. Often these are specialised farms operating on a (semi-) commercial scale near major population centres.

A number of forage production opportunities exist in these systems. They include the use of high-yielding grasses such as *Pennisetum* species which have the potential to provide large quantities of a medium quality basal feed. This reduces the need for large quantities of costly concentrates

Legumes can be used to provide protein to further reduce the amount of concentrates needed on dairy farms. These may be tree legumes grown in blocks or as fence lines for cutting or grazing. They may also be herbaceous legumes grown in combination with grasses or in monoculture as protein banks which can be cut, grazed or used dry as leaf meal (e.g. *Leucaena leucocephala* and *Stylosanthes guianensis*).

## **Tree plantations and other agroforestry systems**

There are over 20 million hectares of coconuts, rubber and oil palm plantations in the region (Horne et al 1994, Stur et al 1994).

Forage opportunities are related largely to the amount of light available for forage growth under the tree plantations. This is limited to a 3–5 year period during tree establishment in rubber and oil palm but good long-term opportunities for the integration of forage exist under coconuts. Naturally occurring forages can be grazed by ruminants without detrimental effects on coconut production, but over time grazing leads to weed invasion (unpalatable species, particularly woody plants) and eventually loss of production. Stocking rates and liveweight gains are generally low. Introduced forages can more than double cattle production under coconuts with minimum inputs. They provide stability by suppressing weeds, resulting in sustainable livestock production with income from the cattle component sometimes exceeding that of copra production (Stur et al 1994).

In forestry and agroforestry projects livestock offer a short-term source of cash income for farmers investing in long-term forestry development, while forages are not only a source of feed but also contribute to reduced soil erosion and weed control.

## **Lowland rice cropping systems**

Rice production is the major land use with little opportunity for forage production in irrigated systems where land is used continuously for cropping. The trend towards mechanised land preparation in these systems reduces the need for feed for draft animals.

Opportunities for forage production are greater in rainfed lowland rice areas, particularly in areas where only one crop can be grown per year. A large part of the cropping area is then available for ruminants grazing crop residues and naturally-occurring forages during the dry season. Opportunities exist to grow special purpose forages (e.g. tree legumes) on small areas which are not used for cropping to supplement the low quality feed resource, and to supply feed during the wet season when there are no other areas available for grazing.

## **Upland rice and other upland systems**

Shifting cultivation or sedentary upland agriculture are often pursued in fragile ecosystems. Livestock play an important role in these systems. Forages, in particular legumes, offer a means of improving and stabilising the fallow or ley areas, reducing erosion and controlling weed growth for cropping areas, in addition to providing feed for ruminants. Farmers rely heavily on ruminant livestock to provide a source of savings, cash income, draft power and animal products.

In eastern Indonesia, the adoption of leucaena-based systems of terracing and live fallow/ley have allowed for the replacement of shifting cultivation with stable sedentary systems (Piggin and Parera 1985). Leaves from the tree legumes are used for livestock feeding during the fallow period; the trees are cut at the end of the fallow period, allowing the planting of a crop—to be grown for one or two years—before the legumes are allowed to grow back.

## **Why have introduced forages not been adopted more widely?**

There is ample evidence to show that introduced forages have resulted in increased crop and animal production in different agro-ecosystems in South-East Asia.

However, there are few areas where introduced forages are used extensively (e.g. high-yielding grasses on dairy farms, seed production in north-east Thailand and pastures under coconuts in the South Pacific). Introduced forages have not been adopted widely in South-East Asia despite considerable effort in evaluation of forages during the last 20 years. New species better adapted to the environmental conditions than the available commercial Australian cultivars were identified but few were tested on-farm to ensure adaptation to the local farming systems. Furthermore, due to a lack of suitable seed multiplication technology (or vegetative propagation systems), suitable species were not exploited. Thus development projects continued to rely only on commercial cultivars from Australia some of which are suitable while some are not.

## **CIAT's regional programme in forages in South-East Asia**

For more than two decades, CIAT has worked on improvement of tropical forages for use in tropical America. Many millions of hectares of planted pastures are now grown in South and Central America. Although the farming systems in tropical America are quite different from those in South-East Asia, there are many similarities in soils and climate. It appeared likely that some of this forage germplasm would be of relevance to South-East Asia.

CIAT was looking for a partner and special project funds to finance its involvement in the region. In 1992, the Australian International Development Assistance Bureau (now renamed the Australian Agency for International Development, AusAID) agreed to fund a small joint CIAT/CSIRO (Commonwealth Scientific and Industrial Research Organisation, Australia) proposal for the "Southeast Asian Regional Forage Seeds Project" from January 1992 to December 1994. Regional forage evaluation and on-farm trials in Indonesia, Malaysia, the Philippines and Thailand confirmed that many of the species selected in tropical America had potential for use in South-East Asia, particularly for the more acid, infertile soils of the region.

The project also highlighted the need for on-farm evaluation (participatory research and development) and the need to develop delivery systems to make adapted forages available to farmers.

## **The forages for smallholders project (FSP)**

In 1994, AusAID agreed to continue funding forage research and development activities in South-East Asia and accepted a proposal for a larger project, the "Forages for Smallholders Project (FSP)", to run from January 1995 to December 1999. The aim of this project is to promote the evaluation and adoption of these forages by farmers and to extend activities to more countries in the region.

The project now includes Lao PDR, Vietnam and South China as well as Indonesia, Malaysia, the Philippines and Thailand. The FSP has regional offices in

Los Banos, the Philippines (staffed by a CIAT Forage Agronomist), and in Vientiane, Lao PDR (staffed by a CSIRO Forage Agronomist).

## Objective of the FSP

The purpose of the FSP is to support partner countries in South-East Asia and so enable them to increase the availability of adapted forages and the capacity to deliver them to smallholder farming systems, in particular in agroforestry and other upland systems.

In order to achieve this, the FSP is aiming to:

- identify forages as components of farming systems for different ecoregions in agroforestry, upland cropping and plantation systems
- integrate forages into these different farming systems through participatory research and development
- increase the capability of national staff through training
- improve the effectiveness of the regional research and development activities through networking.

## Target agro-ecosystems

The target agro-ecosystems for the project differ between countries (Table 1) reflecting the needs of countries. Introduced forages are only part of the feeding system. They need to fit into the particular farming system and contribute significantly to ruminant production. In addition, forages can contribute to environmental sustainability through control of soil erosion, weed suppression and soil amelioration in upland systems. There is a clear emphasis on upland, agroforestry and plantation systems.

**Table 1.** *Target agro-ecosystems.*

|                 | Indonesia | Lao PDR | Malaysia | Philippines | S. China | Thailand | Vietnam |
|-----------------|-----------|---------|----------|-------------|----------|----------|---------|
| Agroforestry    | **        | ***     |          | **          | **       | *        | **      |
| Upland systems  | ***       | ***     | *        | ***         | **       | ***      | **      |
| Plantations     | ***       |         | ***      | ***         |          |          | *       |
| Grasslands      | *         | **      |          | *           | **       |          | **      |
| Lowland systems | *         | **      |          | *           |          | **       |         |

## Mode of operation

The FSP operates as a resource for partner countries and is responsive to their needs and requirements. Mutually agreed upon forage research and development activities are carried out by staff of collaborating agencies, supported by FSP staff.

The participation of farmers is seen as essential in the process of evaluation and adoption of forages. Identification of forages for smallholder farming systems needs to take into account criteria which cannot be simulated on research stations. Smallholder farms are usually complex agricultural systems with introduced forages being only one of many feed resources. Farmer participation is also an important tool in the adoption process.

The FSP takes a regional co-ordinating role, facilitating exchange of information between researchers and development workers, both within and between countries to stimulate discussion and co-ordinate activities. This takes place at annual regional meetings and through the South-East Asian Feed Resources Research and Development (SEAFRAD) network. The FSP supports this network by assisting with the publication and mailing of the SEAFRAD newsletter. Editing the newsletter is the responsibility of member countries (currently the Philippines) and rotates between countries. Originally, SEAFRAD referred only to forage research and development, but member countries requested a widening of the scope of the network to feed resources.

Another form of linkage, which is important for the FSP, is with national and international development projects such as cattle distribution projects. Often animal health, credit and extension personnel are employed by these programmes and feed resources quickly become the most limiting factor. Such linkages will lead to spill-over of results from the project and promote the use of adapted forages.

Lastly, the FSP contains a practical training component on participatory research and development, forage agronomy and seed production. Training is through the "training of trainers" who then hold a series of in-country training courses for a larger number of local staff. There is also a farmer training component, which includes field days, news sheets and technical guides.

### Level of activity

The level of involvement of the FSP varies between countries (Table 2). More research and development activities are to be supported in Indonesia, Lao PDR, the Philippines and Vietnam, but all countries are involved in regional networking.

**Table 2.** *Anticipated level of activity.*

|                        | Indonesia | Lao PDR | Malaysia | Philippines | S. China | Thailand | Vietnam |
|------------------------|-----------|---------|----------|-------------|----------|----------|---------|
| Selection of forage    | **        | ***     |          | *           | *        | *        | ***     |
| On-farm evaluation     | ***       | ***     |          | ***         | *        | **       | ***     |
| Multiplication systems | ***       | ***     |          | ***         |          |          | ***     |
| Staff training         | ***       | ***     | *        | ***         | *        | *        | ***     |
| Farmer training        | ***       | ***     |          | ***         | ***      |          |         |
| Regional network       | ***       | ***     | ***      | ***         | ***      | ***      | ***     |

### Linkages with IRRI and ILRI

The range of activities of the FSP are limited to forage production aspects such as identification of adapted forages, integration of these forages into smallholder farming systems, and the development of seed (or vegetative) propagation systems to make these forages available to other farmers. It is very much a germplasm-based programme.

Research activities which complement the research and development activities of the FSP would be much appreciated. This is particularly important in the context of complex farming systems involving both crops and livestock. IRRI and the FSP are involved in research involving forages and rice production (e.g. tallow improvement and soil erosion), particularly in upland ecosystems. Adding a

livestock component to this research would be immensely beneficial. Other areas of collaboration with ILRI would be possible in forage utilisation in different agro-ecological systems such as agroforestry and plantation crops.

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## Discussion following Dr Stur's paper

Thomas: Werner, you mentioned that one of the previous Australian projects had identified six species. Are you actually moving forward with these six species particularly, or are you also interested in evaluating a wider range of the CIAT germplasm?

Stur: We are exploring these species. There were also some, broadly adapted species which are useful in the region and in fact two or three of these have been around for a long time. But they haven't been taken up and they have not been tested extensively on-farm as was done in the project. We do not want to make our project just another evaluation project of species. We are all going to be judged in the end by how much of this work is in fact used by farmers, so we are certainly going to move ahead with those six species, but we are also looking at more specific systems which has not been done before. If we think there are other species which can improve the system, then we will go back and evaluate those species. So we anticipate different levels of research from adaptive research to development of delivery systems simultaneously feeding in some new species that we already know things about into the research programmes, so we don't have to start from the beginning. For example, one of our projects in Thailand is looking at alternative *Brachiaria* grass species to the one used currently. Other grass species have higher production potential, but cannot be used because they have inadequate seed production, so one project is to actually go back to germplasm banks and look at seed production potential of new *Brachiaria* species. This is one example, not starting right at the beginning—we are starting at the delivery end already.

Thomas: What are the six species that you identified from the previous project?

Stur: These are *Brachiaria decumbens*, *B. humidicola*, *B. brizantha*, *Andropogon gayanus* (in dry areas), *B. brizantha* (S. America), *Stylosanthes guianensis* (CIAT-184—need in S. China) for leaf meal production and lastly improved *Centrosema pubescens* species different from that usual found in the region, aggressive, wide rooting species (suitable for grazing). There are a number of other species which are at the on-farm evaluation stage at this time in different countries.

These six species came out of the original project. We have put a lot more emphasis now in the second phase in evaluation of tree legumes, again developing ways of multiplying these and delivery systems. We are also looking at some *Arachis* species as cover crops for heavy grazing and we are looking for species in fallow improvements.

Little: You mentioned the success of the delivery systems in NE Thailand. What are the key components of getting a successful delivery system working?

Stur: There has to be a need for this particular species. It has to have a role in the farming system which is accepted and seen by farmers in that region. This is the very basic principal and if we don't have demand we are just being academic. If we have a demand then we can certainly develop systems which can deliver those species and this

may be through seed production (and that could be either through government involvement or smallholder seed production schemes) or it could be by vegetative propagation. This is a way of propagating species which works very well in smallholder systems particularly with grasses. Once we have a demand, we have to look at how we can produce these species to satisfy the demand.

Wanapat: A number of pasture improvement programmes in SE Asia have been very successful particularly in the wet season. Would the six recommended species produce efficiently into the dry seasons in terms of productivity and also the efficiency of realisation? This is where the problems are in SE Asia. I would like to see the emphasis being put on the species able to do well in the dry season in order to enhance the availability of feed resources in that particular season.

Stur: Yes, I agree this is a need.

# Priorities and direction for research for more effective use of feed resources by livestock in Asia

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## Abstract

The priorities and direction for research for more effective use of feed resources by livestock in Asia are discussed in the context of prevailing agro-ecological zones, animal production systems, land use, types of feeds available (forages, crop residues, agro-industrial by-products and non-conventional feeds) and the opportunities for nutritional interventions to significantly increase animal productivity. Increasing forage supplies will be constrained by inadequate arable land, unless this is extended to forest and woodland areas, and possibly also in food-feed cropping systems. Potentially important possibilities exist for expanding and intensifying the use of fibrous crop residues (FCR) which account for over 66% of the total feed available from all sources. This can be achieved through well-researched technologies that can be applied singly or in combination, e.g. treatment with alkalis to increase digestibility, rumen manipulation to improve the balance of available nutrients, and supplementation to improve overall digestion, meet nutrient requirements and improve the efficiency of production. The type of supplements include multi-nutrient, non-protein nitrogen mixtures, and by-pass protein sources. Data are presented that provide clear demonstrable evidence concerning the impact of supplementation in large-scale on-farm studies. The potential of leguminous forages is relatively unexplored and their use as supplements can be intensified. Enhancing the efficiency of use of FCR requires both adaptive and applied research. Adaptive research includes identification of principal crop residues, sources and preparation of appropriate supplements. Applied research involves cultivation or production of protein sources, including processing into by-pass proteins, and conservation of biomass for year-round feeding. There is an overriding need for adaptive work concerning on-farm feed resource utilisation which should be seen as a researchable function requiring a multidisciplinary approach. There is also a need to address feed resource constraints within crop-animal systems involving both ruminants and non-ruminants. Priorities and direction for research to address these needs are given, which should provide for increasing the contribution from livestock and the development of sustainable systems of production.

## Introduction

Priorities and direction for more effective use of the feed resources in Asia need to take into account two major issues. One concerns the prevailing agro-ecological

zones (AEZ) and the other the management and use of natural resources, mainly land, crops and animals therein. The AEZ found in Asia are:

- Rainfed temperate and tropical highland system—mainly the Hindu Kush/Himalayan region.
- Rainfed humid/subhumid tropical system—mainly countries in Indo-China, South-East Asia, South China and the South Pacific islands.
- Rainfed arid/semi-arid and subtropic systems—mainly countries in South Asia excluding Nepal and Bangladesh.
- Irrigated/humid/subhumid tropics—mainly countries in Indo-China, South-East Asia and South China.
- Irrigated arid/semi-arid tropics and subtropic systems—mainly Pakistan and India.

Mixed farming is the overriding pattern of agriculture in all these AEZs, and is reflective of the traditional form of agriculture in Asia. These mixed farming systems have certain distinctive characteristics across AEZ (Devendra 1995):

- diversification in the use of production resources
- reduction in, and spread of, risks
- preponderance of small farms
- use of large populations of ruminants (buffaloes, cattle, goats and sheep) and non-ruminants (chickens, ducks and pigs)
- integration of crop and animal farming
- animals and crops play multi-purpose roles
- low input use and traditional systems
- involves the three main agro-ecosystems (highlands, semi-arid and arid tropics, and subhumid/humid tropics).

## Land use

The total land area in South-East Asia is about 434 million hectares. This includes 52% of forests and woodland, 26.5% other land, 17.8% arable and permanent cropland, and 3.7% permanent pasture land. The arable land is already over cultivated, and a significant expansion in this area is unlikely. The area is, however, an important source of crop residues and agro-industrial by-products for feeding animals. Attention is drawn to the large area of about 226 million hectares under tree crops (coconuts, oil palm and rubber) where the native herbage understorey is presently underutilised. Using the pasture under trees for ruminants is a potentially important production system that has not been adequately explored, and one which can significantly increase the current level of productivity.

Development has hitherto over-emphasised the use of essentially lowland irrigated areas to the limits of productivity. Attention now needs to shift to the rainfed ecosystems, a shift justified by two main considerations. Firstly, the demand for food and food security outstrips the potential provided by agricultural growth in irrigated areas. Secondly, these rainfed areas have large concentrations of livestock whose productive potential has remained low and their nutritional needs have not been adequately addressed.

The rainfed ecosystems have considerable agroclimatic diversity compared with the irrigated areas, are generally more fragile and subject to resource degradation. Resource-poor farmers in the upland areas are associated with a complex web of interactions between poverty, agricultural growth and survival in which they perceive short-term survival to be more important than environmental protection. Research and development issues thus require to be more needs driven and recognise the complexity of the task, especially since these issues have, up to the present time, mainly emphasised the lowland, irrigated areas. Since arable land is limited and already over-extended (Table 1) attention must shift to the rainfed lowland and upland areas. It will involve a strong multidisciplinary effort and holistic systems-oriented programmes.

**Table 1.** *Land use in South-East Asia.*

| Type of land use                | Area (ha x 10 <sup>6</sup> ) | % of total |
|---------------------------------|------------------------------|------------|
| Arable land and permanent crops | 77.7                         | 17.8       |
| Permanent pasture               | 15.9                         | 3.7        |
| Forest and woodland             | 225.5                        | 52.0       |
| Other land                      | 114.9                        | 26.5       |
| Total land area                 | 434.0                        | 100.0      |

Source: FAO (1993).

## Animal production systems

A variety of animal production systems exist which are integrated with crops and involve both ruminants and non-ruminants. The systems vary in relation to agro-ecological zone and intensity of the mixed farming operations. These systems have evolved over time, have definite economic benefits and complementary interactions with individual subsystems (e.g. crops, animals or fish) in which the products are additive. Two good examples of sustainable integrated systems are pig, fish, duck, vegetable systems in Indo-China, Indonesia and the Philippines, and small ruminant, tree cropping systems in South-East Asia and the Pacific (Devendra 1993).

It has been recognised in recent years that the emphasis must swing to the development of sustainable small-farm systems. This involves multiple crops and multiple animal use, with integration within or between crops and animals. The small inexpensive, plastic biogas digester is now considered by the Grameen Bank as being a central pivot for integrated sustainable farming systems, with the use of the mineral rich effluent for aquatic plant propagation or algae production for feed fish. The aquatic organisms reclaim nutrient losses (e.g. the elements NPK) from the farming system.

Ruminant production systems in Asia are divided into three categories:

- extensive systems
- systems using biomass from
  - the by-products of arable cropping
  - roadside, communal and arable tethered or grazing systems
  - cut-and-carry feeding

- systems integrated with tree crops such as coconuts or oil palm.

These production systems are unlikely to change in the foreseeable future. New proposed systems and returns from them would have to be demonstrably superior and supported by massive capital inputs and other resources (Mahadevan and Devendra 1986; Devendra 1989). However, it is quite predictable that there will be increasing intensification and a shift within systems (especially from extensive systems to those combining arable cropping) induced by human population growth and the fact that population density and intensity of land use are positively correlated (Boserup 1981). This situation is increasingly likely with the decreasing availability of arable land, which will occur in many parts of South-East Asia.

An analysis of these systems leads to the conclusion that the principal objective should be to maximise the use of the available feed resources. Crop residues and low quality roughages, and various leguminous forages as supplements should be used in appropriate feeding systems to maximum advantage. This conclusion is consistent with the finding in the recently concluded global consultation to define the agenda for livestock research (Gardiner and Devendra 1995) that feed resources and nutrition, are the most important constraints affecting animal production across regions (Asia, sub-Saharan and North Africa, and Latin America and the Caribbean).

## Feed resources

Four main categories of feeds can be identified: forages (include grasses, legumes and browse) crop residues, agro-industrial by-products (AIBP), and non-conventional feed resources (NCFR). Crops grown specifically for livestock, including grasses and legumes represent a relatively small component of the available resources for ruminants because of the unavailability of arable land. The exception to this is the production of legume crops grown as a cash crop at the end of the wet season and before the onset of the dry season.

Crop residues are mainly fibrous crop materials that are by-products of crop cultivation. Because of the emphasis and intensity of crop production in Asia, these form a high percentage (over 66%) of the total volume of feeds produced. These crop residues have a low crude protein content, low digestibility and are often deficient in minerals.

AIBP are less fibrous, have relatively more digestible nutrients and are often relatively high in protein. Good examples are copra meal, rice bran, cottonseed meal and palm kernel cake. Effluent from refining palm oil and molasses are low-protein by-products that are high in minerals and fermentable substrates. NCFR are identified separately and include all those feeds that have not been traditionally used in animal feeding. In Asia, NCFR are diverse and include coco pod husks, pineapple waste, distiller solubles and poultry litter. It has been estimated that the total availability of feed resources other than grasses from traditional sources and NCFR was  $1996 \times 10^6$  t of which about 47% were NCFR (Devendra 1992a). It was also estimated that approximately 80% of the total feed available is potentially best suited for feeding ruminants. The most important function of these animals in the Asian and Pacific region is therefore the utilisation of carbohydrate resources in fermentative digestion. These resources are not sufficiently digestible by monogastric animals to support their production.

## Supplements for ruminants

Almost all the carbohydrate resources fed to ruminants in the tropics are low in total nitrogen and protein and are also often deficient in some essential minerals. Supplements that can be used to provide these different nutrients are discussed below.

### Oil seed meals

Much of the increased requirements for protein meals in some parts of Asia can be met from the reduction in export of by-product vegetable protein meals to Europe and North America. In many regions the available protein resources are fed to pigs and poultry. Often the need is therefore to find or produce a suitable protein resource for ruminants. One approach concerns leguminous forages.

### Leguminous forage proteins

There is at present, a concerted but perhaps over-focussed initiative on a very limited number of forage species and their development throughout the region. The main thrust to date has been to provide protein (and energy) from forage legumes in pasture, or utilise a protein source such as fodder banks. Biomass and protein production have been the criteria for selection. Little consideration has been given to the form of protein in such forages. Proteins present in green forages are usually highly soluble enzyme proteins which are easily fermented in the rumen; the amino acids are largely converted to ammonia, and therefore provide little or no essential amino acids to the animal. It has been demonstrated that in many situations the leguminous forage, in small quantities, functions to stimulate rumen fermentative efficiency. They therefore give no extra benefit over that provided by a molasses–urea multinutrient block. Research on forages should be continued, but it is equally important to find ways to protect the proteins. This may be accomplished, to some extent, by simple sun-drying (Leng 1995).

The presence of tannins (1–3%) is the most effective means of protecting the protein in fresh legume forages. Tannins protect the protein from rumen degradation as occurs with *Lotus* spp (Barry 1983). Unfortunately in tanniniferous forages, tannins are present in concentrations that are extremely variable both between and within forage/foiliages. The important factors that influence tannin levels in a foliage source include plant growth conditions, stage of growth, damage from insects or herbivores, harvesting methods and feeding techniques for the forages. There is also considerable doubt as to whether tannins reversibly bind proteins (see Van Soest 1994). Thus, the factors that influence tannin content and its irreversible or reversible binding of protein still need considerable research.

Trees and shrubs that contain tannins often react quickly to foliage damage by increasing their tannin content up to 300%; this often happens soon after a tree is damaged (see Van Hoven 1985). Identifying the factors that influence tannin levels is critical to identifying the range and variety of species that could be used for ruminants. Selection of forage legumes containing tannins that are high in protein could be particularly important to further enhance the use of protein banks.

There are attempts to use recombinant DNA technology to introduce tannin synthesis into forage legumes that previously lacked these compounds (CSIRO Plant Industries, Canberra).

## Fodder tree/shrub proteins

Some emphasis is being focused on fodder tree plantations (Devendra 1990). Trees require more emphasis because they are multi-purpose and therefore readily fit into an integrated farm approach. They also meet many of the requirements for sustainability of farming systems and can be used in grazing systems or where cut-and-carry grass is used to feed housed/tethered animals. Trees also provide fuel resources for households, often reducing the need to purchase other fuels.

The attributes of trees in farming systems include:

- They provide high protein leaf forage and some provide large quantities of fruits or pods, which can be used as a relatively high energy, concentrate feed.
- They are perennial and often drought resistant.
- Many species are legumes and/or also mobilise unavailable P through root associated fungi. They are also deep rooted and take up minerals from deep soils that are not exploited by grasses and crops.
- They provide sustainability when planted in pastures, protecting the soil against wind and water erosion and recycling nutrients from deeper soil layers with the fixation of N in leaf mulch on the soil surface.
- They store carbon dioxide from the atmosphere reducing atmospheric build-up.
- They provide fuel (an ever increasing problem for the poor) and replace fossil fuel energy with wood energy, again contributing to lowering of carbon dioxide emissions into the atmosphere.
- They also provide numerous other advantages and uses, e.g. shade, fenceposts, medicants etc, and are a critical fodder reserve during drought.

*Fodder tree species.* In grazing systems on neutral to alkaline soils, *Leucaena leucocephala* has already proved its usefulness. However, infestation by the *Leucaena* psyllid has reduced the areas where the tree can be grown.

Many fodder trees are known to indigenous peoples who feed them to their livestock. Pods as well as leaf foliage are often sought after as ruminant feeds—*Acacia nilotica* pods are used extensively for feeding to goats in India and *Prosopis juliflora* pods are finding their way into concentrate feeds in a number of countries, particularly in Brazil (Dutton 1992).

Useful species include *Leucaena*, *Tagasaste*, *Acacia*, *Gliricidia*, *Erythrina*, *Calliandra*, *Prosopis* and *Tricantera*. *Tricantera* is fed to pigs and poultry in South America. There is a continuing need to identify useful trees to fit with the local environment and soil conditions. However, for livestock, tree foliages are especially important as these will essentially provide supplements to pasture or other biomass and will be fed at low levels in a diet. Often the level of inclusion in a diet is below that at which deleterious secondary plant compounds have an effect. This then broadens the scope for the use of different species. However, the foliages with secondary plant compounds are often rejected at the first screening level for useful plants.

*Need for processing of proteins/secondary plant compounds from trees.* There has been little research to process tree foliages and fruits or pods to maximise their nutritional value as supplements. Heat, chemical or physical treatments to develop protein supplements from trees/shrubs that are rumen-protected but are intestinally digestible are recommended as priority research. Simple mixing of high-tannin and

low-tannin foliage may result in better utilisation of tree fodders. Sun drying tree foliages appears to increase their nutritional value as supplements, suggesting that the treatment protects the protein from rumen degradation (Norton 1994).

### **Research needs for fodder trees**

Both forages and tree fodders require continuing research. The areas include:

- selection of species and how to manage plantations
- harvesting and/or grazing management
- special studies of secondary plant compounds; the influence of tree management, harvesting, soil fertilisation and water regimens
- the effects of secondary plant compounds in the animals
- foliage and fodder processing to ameliorate adverse effects of secondary plant compounds and enhance the utilisation of protein.

The major issue with fodder trees is where to grow them, as there is little land available for cropping. The integration of fodder trees in marginal lands (because of topography, aridity, acidity, salinity etc) or with plantation crops appears to warrant considerable research.

### **Aquatic plants**

Aquatic plants are a further resource that can be produced on presently underutilised areas of water, and fit into a sustainable farming systems approach. Most research has focused on the use of *Azolla* with less emphasis on water lettuce (*Pistia* spp) and water hyacinths (*Eichornia* spp). All water plants are low in dry matter, low in fibre but variable in protein.

Duckweeds (members of the Lemnaceae) have recently been singled out for attention because of their very high protein content, high biological value and low fibre which makes them very suitable as a protein or food source for pigs, poultry and fish. Duckweed is also a potential N or protein source for ruminants and a source of P when grown on water with a high P content (see Skillicorn et al 1993; Leng et al 1994).

Under ideal conditions duckweed may have 45% protein (more usually 30–35%) in the dry matter and up to 1.5% P which appears to be totally available and is extremely high in vitamin A (Leng et al 1994). It has the potential to produce 9–18 t of protein/ha per year under good conditions. Considerable research is now needed on aquatic plants with emphasis on growth conditions to maximise protein and minimise fibre contents. Techniques for feed processing such as drying (as the plant is 6–8% dry matter), preservation of wet materials and retention of the high biological value of the protein preserved wet or dry are also needed. Treatment to ensure protein protection, if it is to be fed to ruminants, may also be needed.

There is considerable scope to set up duckweed and *Azolla* farming on sewerage and industrial waste waters high in phosphorus. However, they are more suited to small integrated farming systems to provide a mechanism to recycle a high protein supplement for animals. They also recycle P, N and K specifically, and a number of other minerals found in solids or effluents from animal production.

# Feed resources for pigs/poultry

## Availability of feed grain

Inevitable fuel cost increases will set an upper limit on food crop production through its multiplier effect on all costs of crop production. The constraints imposed by rising fuel costs, together with plateauing of the genetic improvement in cereal yields, increasing land degradation and decreasing land size per head of population as the population grows will affect the intensification of some livestock systems. Intensive pig and poultry production based on cereal grains (as practised in industrialised countries) will become unacceptable or uneconomical in most developing countries except where these industries supply the wealthier markets, such as those provided by tourists and the urban middle class.

At the present time, intensive pig and poultry industries are the major growth areas providing meat and eggs for the Asian region even though there is enormous potential to increase total meat and milk production from ruminants.

There must be serious doubts about the desirability of supporting the continued growth of the intensive pig and poultry industries in Asia. The production systems based on inexpensive oversupply of world grain are often peri-urban and are maintained at considerable cost to the environment. The research technology for development of this industry will be transferred from industrialised countries by entrepreneurs and these systems should therefore be left to the private sector. However, the small-scale production of pigs and poultry based on alternative feeds/management should be approached as part of the traditional and integrated farming systems of Asia (Devendra 1995). Increased research and development of these systems can significantly increase their current level of output.

Mitchell and Ingco (1994) support earlier predictions that there will be a continuing availability of surplus cereals on world markets at competitive prices for pigs and poultry production to meet urban middle class markets. This scenario is based on the view that increasing income will change diet selection and reduce human requirements for grain consumption. Grain supply will increase due to increased inputs into production in the grain exporting countries and cereal prices will remain competitively low. These factors are expected to favour increased pig and poultry production. However, China alone is projected to require to import  $300 \times 10^6$  t of feed grain by the year 2010 (Brown 1994). This is almost double the predicted surplus for that year.

Thus, it appears that the dependency on grains for extension of pig and poultry production is at the best a precarious option. A collapse of the burgeoning and established pig and poultry industries because of increased costs of grain could be devastating for many countries and therefore, for increased food security alone, there is a need to develop alternative small farmer systems. It appears that there is also a need to concentrate on improving ruminant production—because of the large feed biomass that will always be available—and to develop unconventional feeds and appropriately modify traditional feeding systems for monogastric animals in Asia.

A pertinent issue for ILRI to consider therefore is the development of integrated farming systems based on local and non-conventional feeds. These systems should include ruminants fed crop residues and sustainable production systems for pig and poultry.

## Village pig–poultry production

Throughout Asia there exists a massive, unstructured village-level pig and poultry (including ducks) industry, that is largely unserved by research. This industry is based on scavenging feeds from farms and households. The production of ducks on rice fields or in lagoons is often sophisticated, and traditional systems in Indonesia (for example) are highly efficient particularly in egg production. In general, however, scavenging pigs and poultry are inefficient enterprises limited by poor nutrition and hygiene, disease and lack of housing. These systems have received little attention, perhaps because of the difficulties of researching such diverse systems. In addition, the research has been under financed and poorly designed and often has not included participatory on-farm activities.

The recent introduction of a small amount of attenuated Newcastle disease virus in a feed supplement effectively immunised poultry under village production systems in South-East Asia, increasing survival rate enormously (Spradbrow 1992). This raises the issue of how feed resources and feeding systems can be developed to keep up with the increased survival rate. Identification of the order and magnitude of nutritional deficiencies in traditional pig and poultry production systems and supplementation of the limiting nutrients could have a major impact on production if major disease problems are controlled simultaneously (Spradbrow 1992).

In Vietnam, there is a traditional system of duck raising which includes lagoon production of duckweed. The lagoons are fertilised with excrement from humans, ducks, pigs and cattle. Freshly harvested duckweed is mixed with rice polishings and cassava wastes as the main protein resource for raising ducks and the runoff water is used for irrigation. This is an excellent example of traditional systems that require study.

## Local feed resources for pigs and poultry

*Sources of carbohydrate/energy.* There are many alternative carbohydrate sources which can be used, particularly by pigs. These include cassava roots, sweet potatoes, reject banana fruits, cereal brans, molasses and sugar-cane juice, food waste from urban communities or, where available, inexpensive vegetable oils (Preston and Margueritio 1992). The opportunity cost of using any of these carbohydrate sources depends on a number of factors, but there are many combinations of food that can lead to moderate levels of pig production .

Diets based on urban household waste for pigs, traditional in Europe in the 1940s, and molasses-based diets have been used in recent years in Cuba and South America (Figueroa and Ly 1990). Fractionation of sugar-cane into juice and fibre, and the use of the juice for pigs and the fibre and residual sugar for ruminants, respectively, has been shown to be feasible on small- to large-scale production units (Preston 1980). The use of high levels of oil (40–50%) from oil palm in the diet of pigs has recently been reported to support reasonably high levels of growth (Ochampo 1995).

*Sources of proteins.* Protein meals extracted from oilseed, chicken offal meals, hydrolysed feather meal, seeds, foliage of some food crops, fly larvae, duckweed, *Azolla* and other aquatic plants and earthworms have all been researched in a rather superficial way as protein sources in diets for pigs. Improved village or backyard pig production systems based on non-conventional foods could be very effective in increasing meat availability that would benefit a large number of poor people.

# Priorities for nutrition research

The major emphasis on agriculture in Asia will continue to be on food production. However, as the middle class expands with increasing standards of living, animal products must assume an increasing component in overall primary production output. Most animal industries other than the high technology pig and poultry industries are secondary to, but interrelated with, crop production. The secondary nature of animal products for small farmers has resulted in ruminant production being under financed and characterised by low growth rates, late maturity and extended interbreeding intervals of the animals. To increase ruminant productivity substantially from its present low base does not appear to be a major task. It is, however, important to understand that for crop farmers, the priority in terms of ruminants is usually draft power and not increased meat and milk production.

Opportunities for improving nutrition are governed largely by the availability of digestible biomass. Although forests and woodlands and other lands in South-East Asia combined represent 78.5% of the total land area, in terms of provision of fermentable biomass, this area possibly provides less than that from the arable and permanent crops. The total biomass production of permanent pastures is almost negligible relative to that of cropping lands (Table 1).

The main objective is to increase ruminant production within the cropping areas based largely on crop residues, agro-industrial by-products and non-conventional feeds. The use of biomass under plantation management, however, is a largely unexploited resource for ruminant production that deserves considerable emphasis.

## The major issues in nutrition research

### Ruminants

- Identification of the major conventional and non-conventional biomass resources available in sufficient quantities to be the basal diet for ruminants.
- Consideration of their nutrient composition and digestibility and, where appropriate, establish economical treatment processes to improve digestibility.
- Identify the appropriate supplements to provide:
  - feed nutrients deficient for optimal microbial growth
  - nutrients to increase protein supply for absorption of the intestine (by-pass protein) and other nutrients required by the animal (P, Ca etc)
  - potential protozoal toxins to remove the anti-nutritional effects of protozoa (see Bird 1995).
- Establish response relationships to supplements in ruminants fed treated feeds to increase digestibility.

### Monogastrics

- Identify alternative carbohydrate resources or feeds.
- Identify potential supplements to balance diets based on non-grain feeds or those of scavenging monogastrics .
- Measure response relationships to graded inputs of protein meals, minerals etc.

For both ruminants and monogastrics it will be necessary to monitor and take advantage of the effects of any inputs into animal production on nutrient flows within the integrated farm and how these affect crop yields, fuel supply and production from other animals.

### **Research: Feed resources**

- Where protein resources are scarce the priority will be to produce on farm protein sources which may be conventional (e.g. legumes and tree foliages) or non-conventional (e.g. *Azolla* and duckweed).

## **Nutritional strategies to increase productivity from animals**

### **Intensifying the use of crop residues**

There is a real and obvious desire by scientists to progress beyond the boundaries of present knowledge in animal production and ILRI has a mandate for long-term research on animal production for at least 10 years. However, substantial increases in total animal productivity could be achieved if the established nutritional knowledge were to be applied widely throughout the region. Enormous research effort has targeted improvement of ruminant production from crop residues (straws) and high biomass agro-industrial by-products (e.g. sugar-cane bagasse, molasses etc). The key need is to determine how to make best possible use of crop residues under the prevailing regional and socio-economic conditions.

The major research needs are those that:

- identify economical and appropriate technologies to improve the potential digestibility of crop residues
- develop the most appropriate strategies to enhance rumen function and the means to administer these supplements
- develop appropriate means of manipulating net rumen microbial growth efficiency
- identify and/or develop the feed resources to provide by-pass nutrients
- demonstrate to farmers the profitability of the responses to appropriate packages of technologies
- provide or ensure post-production facilities for efficient marketing of the products which should have added value wherever possible.

### **Enhancement of the utilisation and digestibility of straws through alkali treatment**

There is now a major developmental model for the use of supplementation strategies and the technologies of straw treatment to improve ruminant productivity. Under the auspices of FAO, a pilot project was set up in southern China to develop cattle feeding systems using straw and cottonseed cake (Dolberg and Finlayson 1995). The success of the project is indicated by the statistics of straw treated and fed to cattle in the region (Table 2).

**Table 2.** *Development of beef, production systems based on ammoniated straw in southern China.*

| Year             | Farmers<br>(x 10 <sup>6</sup> ) | Straw quantity<br>(tonnes x 10 <sup>6</sup> ) |
|------------------|---------------------------------|-----------------------------------------------|
| 1985             |                                 | 0.003                                         |
| 1986             |                                 | 0.042                                         |
| 1987             |                                 | 0.148                                         |
| 1988             |                                 | 1.480                                         |
| 1989             |                                 | 1.830                                         |
| 1990             |                                 | 2.570                                         |
| 1991             |                                 | 3.870                                         |
| 1992             | 2.2                             | 6.000                                         |
| 1993 (estimated) | 3.3                             | 11.000                                        |

Source: Dolberg and Finlayson (1995).

## Strategic supplementation

Success has been achieved through local research that defined the nutritional supplements needed within the socio-economic realities of the area. For example, growth response relationships in cattle fed ammoniated straw to cottonseed cake inputs were developed. These results, together with a number of response curves for cattle fed low quality forage and supplemented with cottonseed meal are shown in Figure 1. The effects of various treatments for adding ammonia to straw were also evaluated. As the technology is taken up by more and more farmers, alternative sources of protein will be needed and research may pay off where the cottonseed cake protein is further protected to reduce the inputs necessary. When carcass composition and quality becomes a major market criteria, further studies to alter carcass composition (e.g. feeding protected fat) may also be needed.

**Figure 1.** *The response in liveweight gain of cattle fed basal poor-quality forage supplemented with cottonseed meal.*

The above example of a research and development strategy demonstrates the way ahead for the most rapid development of ruminant production systems in cropping areas, i.e. to adapt and extend the already known technologies to use local biomass resources to demonstrate the benefits of supplementation of crop residues fed to small or large ruminants and show the additional benefits from alkali treatment (urea ensiling) of straw for small farms.

The lack of appropriate supplements or the infrastructure for manufacture and distribution of supplements are primary limitations. Cash flow for purchases of supplements and the knowledge of how to use these are also critical constraints to their effective use, particularly for the small, resource-poor farmer.

# Research requirements to establish appropriate supplements for low quality forages for ruminants

The supplements needed to balance low digestibility roughages for feeding to ruminants have been discussed above. They are now classified according to their role as:

- Nutrients essential for efficient microbial growth in the digestive systems of ruminants, which include:
  - Multi-mineral sources, e.g. molasses or residues from molasses fermentation (spent liquor), chicken litter or poultry manure made into loose mixtures, liquid mixtures or the same mixes solidified into blocks .
  - Non-protein nitrogen sources include urea, chicken manure/litter and soluble proteins from leguminous forages, seeds and agro-industrial by-products (e.g. soybean curd).
- Supplements that increase protein digested in the small intestine (i.e. by-pass or escape protein or rumen non-degradable protein):
  - By-pass protein sources which include protein meals that (i) have been heat treated in processing, (ii) contain a low level of tannins (1–3%), (iii) have simply been dried, or (iv) have been heated with reagents that make the protein insoluble (some protective agents include xylose, glucose, formaldehyde, gluteraldehyde etc).

The best preparation and sources of supplements depend on locality. For example, recent studies have demonstrated that simply drying leaf foliages has an effect on how the material is viewed as a supplement (Table 3). The fresh material appears to enhance only rumen fermentative digestion but the nutritional value of the dry leaf meal appears to be enhanced which may be due to insolubilisation and thus its content of by-pass protein.

**Table 3.** Comparison of the effect of tree foliage supplements fed fresh or after drying to goats fed a basal diet of rice straw.

| Foliage supplement            | Forage intake (g/kg LWt/d) |     | Basal diet | Dry matter digestibility (%) | Growth rate (g/day) |
|-------------------------------|----------------------------|-----|------------|------------------------------|---------------------|
|                               | Tree foliage               |     |            |                              |                     |
|                               | Fresh                      | Dry |            |                              |                     |
| <i>Albizia chinensis</i>      | 7.5                        |     | 18.5       | 51                           | 0                   |
|                               |                            | 7.5 | 16.5       | 44                           | 54                  |
| <i>Calliandra calothyrsus</i> | 7.5                        |     | 18.5       | 47                           | 2448                |
|                               |                            | 7.5 | 18.5       | 44                           |                     |
| <i>Gliricidia sepium</i>      | 7.5                        |     | 18.5       | 56                           | 12                  |
|                               |                            | 7.5 | 15.5       | 47                           | 42                  |
| <i>Leucaena leucocephala</i>  | 7.5                        |     | 15.5       | 49                           | -18                 |
|                               |                            | 7.5 | 18.5       | 47                           | 0                   |
| <i>Sesbania sesban</i>        | 7.5                        |     | 14.5       | 53                           | 0                   |
|                               |                            | 7.5 | 17.5       | 52                           | 54                  |

Source: Norton (1994).

## **Draft animal power**

Animals are often critical in cropping areas since they provide a means to recycle nutrients to crops and also increase the fertility of land. The draft animal plays this role in many small farms providing fertiliser for crops such as rice, but pigs and other animals can also be important (e.g. pigs in Vietnam, see Vo-Tung Xuan et al, this proceedings). Although in some situations draft power is being replaced by motorised equipment, farmers in Asia still predominantly depend on work animals (cattle, buffalo, horses and donkeys). The continued use of draft power into the foreseeable future seems assured on many grounds, especially in socio-economic terms and with any price increases for fossil fuel in general. This will be accompanied by a return to the work animal both for their contribution of manure and for transportation and cultivation. Concerning the nutrition of draft animals, there is considerable wisdom in most countries where they are raised by specialist cattle producers. For example, in India 20 million cows are kept to produce replacement bullocks. In general, research needs include nutritional studies to:

- promote attainment of potential adult live weight
- ensure maximum nutrient extraction from the diet

These two requirements may be achieved through supplementation of their poor quality forage diets to create optimum rumen fermentation conditions (see Preston and Leng 1986; Preston 1990).

## **Production from small ruminants**

### **General considerations**

Although the nutritional principles of using agro-industrial by-products and other sources of biomass are the same for both large and small ruminants, there are some advantages in using sheep and goats. These include:

- Some sheep and goat breeds are prolific and therefore can rapidly increase ruminant populations numbers.
- Given the opportunity, goats have the ability to select a more nutritionally valuable feed from mixed sources of nutrients; they depend on different feeds from sheep and cattle in mixed pastures.
- The goat has a capacity to detoxify some anti-nutritional secondary plant compounds, largely in the liver. This broadens their feed base and, in the semi-arid areas, this increases the available biomass including high-protein shrub and tree foliages that may not be consumed by cattle and sheep.
- There are breeds of goats and sheep that are highly efficient dairy animals and fit well into small, integrated farming systems.
- The skin of goats is often as valuable as the meat.
- Small ruminants require relatively small investment to purchase breeding stock and to feed.
- They can be managed by women and children.
- Unlike the large ruminants in Asia, the male is as valuable as the female.

- They are the preferred meat in many areas and their small size means that refrigeration for storage of meat is often not necessary. There appears to be no significant taboos against them for human food.
- They are highly suited to grazing under plantation crops; in agroforestry development or in special combinations of fodder trees/shrubs in pasture, particularly where intestinal parasite control is effective.

Multiparous goats/sheep that breed twice per year have the potential for highly efficient conversion of biomass to animal product. The role of the multiparous goat or sheep could be more analogous to the pig in industrialised countries and they have the major advantage that they need not compete for human food and that the production of their forage resources is achieved without excessive energy inputs.

With the already available technologies, i.e. disease/parasite control/supplementary feeding and the use of various forages and a variety of other feed sources of moderate to high digestibility, there is potential for substantial productivity from small ruminants. One female goat well managed, could produce say six kids per year weighing, at slaughter, 20–30 kg each. This is to be compared with the production of 50–100 kg live weight from buffaloes/cattle largely over a 2-year period that would consume at least 16 times the basal feed resource in that time. There is a particularly great opportunity to develop goat and sheep production from forages growing under tree crops. Extensive reviews indicate that the contribution to total farm income from goat rearing was: sale of animals 22.0–25.8%, milk 19.7–76.0%, and manure 1.0–4.5% (Devendra 1992b).

## **Research approaches**

### **Adaptive and applied research for small ruminant production**

- Identify feed resources and protein supplements and establish growth trials with response relationships to the most critically deficient supplement fed with either treated or untreated biomass or in grazing situations .
- Establish the effects of supplementation of multiparous small ruminant on their fecundity and fertility.

### **Basic research**

- Identification and study of genotypes for multiple ovulation (prolificacy) and ability to breed year round aiming at development of strains with high or medium prolificacy to fit the appropriate farming situation.
- Studies of the interaction of nutrition, disease and reproductive performance, including ovulation rate, conception rate and the survival of young.
- Studies on how to manipulate reproductive capacity to improve efficiency of production of total offspring.
- Studies on the mechanism of detoxification of secondary plant compounds in liver or rumen.

## **Specialist livestock husbandry**

The secondary nature of ruminant production to cropping on small farms in Asia is the direct cause of the present, universally low, ruminant productivity. It may be

opportune now to develop systems where milk and meat become a focal issue within the farm but are still integrated into the farming system of a village.

A new approach might involve the encouragement of specialist animal producers outside the integrated farm, in which the specialists purchase the inputs (e.g. straw etc) and sell the residues (e.g. manure) to the crop farmer. This is a strategy that could be developed for the landless rural people who are increasingly under-privileged. The reason behind these suggestions is that it is doubtful whether traditional farms with crops as their major output can provide sufficient input into ruminant systems to meet the increasing quality control that is being demanded by more discerning markets. The potential to create "animal farms" closely associated with crop farms will depend mainly on the development of quality markets and sustainability of the system. Separate cattle production units would fit into the intensive rice farming systems where increased removal of rice straw from paddy fields now appears to be necessary to lower soil carbon and nitrogen pools (Fischer, this proceedings).

## **Environmental issues**

Future animal productivity and environmental considerations within aid agencies and government legislation are likely to have a large impact on the direction of future research. Considerations which will come into play include the need to control gaseous pollution of the atmosphere and pollution of surface and ground water. The pressures will be applied largely through inter-government interactions, national legislation and aid agencies anxious to ameliorate anticipated world problems. The issue of sustainability of the farms, however, has to be the uppermost consideration which in every situation will be difficult to monitor because of the long time period over which measurements are needed. Traditional systems are generally sustainable and there should be a concerted effort to build on such systems or at least characterise and monitor them and identify where they have been disturbed beyond sustainability.

## **Institutional considerations**

In the Asian region, the issues are mostly associated with small farm enterprises and therefore integrated farming. Five key requirements are essential if new research programmes are to be accepted and implemented to increase the value of livestock production. These are:

- Commitment to inter-disciplinary research within integrated systems.
- Consideration of pollution control and recycling of nutrients as areas for study.
- Formulation of research programmes that are farm (rather than laboratory) oriented and participatory, and consideration of post-primary production components.
- Establishment of effective, two way information transfer between farmers and scientists.
- Determination of effective means of monitoring the potential sustainability of farming systems.

## Basic and institutional research

There are well founded arguments that have established that future improvements in animal production require research aimed at developing the more fundamental aspects of animal production. Currently, biotechnology, in particular recombinant-DNA technology, has shown some promise for future application. There are good arguments for the development of such studies, particularly where the boundaries for research are established according to the needs or the peculiarities of developing countries and therefore are unlikely to receive attention in the industrialised world. However, the nature of such research requires extensive laboratory facilities and it is undoubtedly expensive relative to "on-farm" or applied research (Leng 1990). There are a large number of possibilities for the direction of such research but, the pay off in relation to increased sustainability, profitability and productivity of animal farming will remain a major gamble. However, it would be inappropriate not to outline in this consultation some areas of research that might apply to ruminants fed poor quality forages and pigs and poultry fed non-conventional feeds.

Within the area of ruminant nutrition, the most appropriate areas for understanding and manipulation centre on improving feed utilisation through manipulation of the rumen microbes or the feed. A brief summary of these is given below:

- Enhancement of microbial-fermentative digestion of cellulosic biomass.
- Enhancement of microbial growth efficiency and improving microbial flow or protein relative to energy from the rumen. This includes control of protozoa using feed additives and/or immunisation techniques.
- Prevention of protein degradation by rumen microbes; development of novel methods of protection of protein in plant materials such as the use of immunisation techniques to inhibit proteolysis.
- Detoxification of anti-nutritional factors in feeds by rumen microbes, treatment of plant material or manipulation of the plant.
- Screening of plants for high protein yields and secondary plant compounds that promote rumen by-pass of the protein.

For pigs and poultry, again, the major areas for manipulation are those that alter the non-conventional feeds to support higher feed conversion efficiencies and include:

- Simple methods to detoxify a range of seeds particularly from trees and forages.
- Simple methods to remove secondary plant compounds from agro-industrial by-products such as gossypol in cottonseed meal.
- Treatment of high fibre protein meals to lower the fibre content and increased incorporation rates into non-conventional feeds.
- Simple methods to prevent aflatoxin problems associated with protein meals (e.g. binding with bentonite) .

## Overview

In most countries of Asia the major constraints to ruminant production are associated with slow growth which results in delayed maturity and long intervals between births. Large improvements in production result from research that

establishes feeding strategies aimed at increasing growth rate and lowering the age of puberty, and ensure that a mature cow calves annually. For Asia, non-conventional feeds for pigs and poultry must be researched but the overriding issues are those that pertain to the production of all animals within the farming systems.

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## Discussion following the two papers on forages and feed resources (Dr Stur, and Drs Leng and Devendra)

- Fitzhugh: Ron, thank you for an interesting and stimulating talk. Have you done any analysis regarding the effectiveness of feeding crop residues, by-products, vegetable oils, and, so on—the list of feeds that you identified—to alternative monogastric systems or to ruminants, because it would seem to me that is a comparison that we will have to look at, accepting that grain-based feeding systems for livestock will probably not be cost effective in the future?
- Leng: As far as ruminants are concerned we have looked at virtually the whole list and looked at it in terms of efficiency. The response to by-pass protein is typically the same. The response curve depends primarily on the digestibility of the initial component, so if you have 45% digestibility it will generally follow a certain pattern; if it is 55% it generally follows the pattern which is parallel and higher. With fat, we have been working with high levels of fat in the diet of ruminants. We insolubilise the fat by simply treating it with calcium oxide, and adding a little water. The heat of the reaction hydrolyses the fat and forms calcium soaps which then can be incorporated into the rumen diet at levels as high as 20% without any adverse effects in the rumen. Then if we take an agro-industrial by-product or a crop residue like straw, and we can get 800 or 900 grams a day gain.
- We don't need the modified proteins with monogastric animals. Their limitations are in terms of fibre, in particular of vegetable proteins, and it then becomes a matter of being able to get a high protein biomass from plants which are low in fibre. Duck weed in some traditional systems is far superior to the *Azola* only because it has got less fibre. However, if you grow duck weed under poor nutrient conditions fibre increases and protein drops—the nutritional value is changed. So, yes we and others, e.g. Wanapat in Thailand, Ocampo in Colombia, have done quite a lot of this work.
- Fitzhugh: As we talk here about research priorities, we need to consider milk production as well as meat production from ruminants, and we should also consider that ruminant production systems can be segmented, so that you can develop the efficiency of the total system.
- Leng: I agree with you on milk. It is a most difficult proposition in most of Asia because the milking animal does not become valuable until it is a milking animal, and therefore the inputs a farmer is willing to use are very limited in the early part of its life. But, for example, in the Indian situation we have introduced into about a third of the feed mills of India the concept of by-pass protein feeding and we have literally doubled milk production in those villages that have taken up the technologies. Something like 200,000 tonnes of by-pass protein are being fed through the National Dairy Development Board. Where that has been done, the big benefits have come through reproduction, through decreased calving interval, resulting in more animals being incorporated into the national herd. Where imported Friesian are being used, the biggest problem we have is that they don't come into milk for two years. If we can get them back into milk every 15 months, we

can almost double milk production overnight. If good forages with high nitrogen content or molasses–urea blocks are fed with crop by-products which are typically used in India we could get young stock lactating at 2–3 years of age rather than 4–5 years of age; we can increase productivity through reproduction.

Little: Werner. Hypothetically, if one came to you to recommend, amongst the species that you have been working with, a proposition for a rather large-scale project involving a number of farmers for whom one is going to produce feed to produce beef or milk etc, how happy would be to recommend the utilisation of a number of these species in particular environments?

Stur: This is a rather tricky question and in some ways it's a little bit early as far as the CIAT work is concerned, because we really only started off in the last year or two. Drawing on experience from other people and with national programmes, we would be probably quite happy to recommend a number of species for plantation systems for the humid/subhumid tropics. We would certainly be happy to make recommendations for high input systems which have been well developed. The areas where we are still very weak is the integration with crops, when we are talking of fallow periods and soil improvement over time. I think there are a number of tree legumes around the region which we know we can use. Utilisation aspects become particularly important here particularly at the moment because there is a new big germplasm based project starting on *Leucaena* evaluation, which is a world-wide evaluation. Most of the materials are unknown to us and we don't know how it is going to fit in as far as the utilisation aspect is concerned.

Little: Thank you. Actually that was very much the response I had in mind. So the question I was going to direct to Ron Leng is if one is not confident about recommending things in the integration with crops (because Ron mentioned the problems of providing forage specifically for livestock and one understands completely the problems that there are here), there is nevertheless a lot of work that is going on in relation to intercropping, e.g. growing legumes along with, or in between, grain crops and various other crops and some specialised legumes that are going to improve the crop yield and the residue yield and of course provide something for the livestock. It seems to me that there is a pretty huge potential that hasn't yet been looked at.

Leng: You are absolutely right. I think that for the grasses how much digestible biomass we can produce should be the major criterion. But if you take all the cropping attributes that can come from growing legumes and their intercropping with crops etc, then there is a very good case for forage production. But I don't think there is a good case for forage production for animal production alone—it is part of an integrated farming system. There seem to be two constraints to me to develop under coconut. One of them is that there are virtually no proteins in the system for the animals even though they get legumes at times, and the other is the intestinal parasites problem particularly which develops in those shaded areas where larvae etc find real potential to bloom. Now copra meal is being imported in massive

amounts into Australia to feed our cattle at grass. Yet combinations of that forage production with copra meal would again double the value of both things, the supplementation and the forage that is there. Control of parasites using anthelmintic blocks is showing tremendous potential particularly under coconuts, and having effects particularly on reproduction. If I gave the impression that it is not worth growing forages, that is not the impression I wanted to give. What I was trying to correct is the idea that we don't have enough forage and the quality of that forage is too low.

- Wanapat: I would just like to make additional comments on Professor Leng's recommendations in regard to research priorities particularly in ruminants. He seems to have put a lot of emphasis on the locally available feed resources, but I still feel that it is essential to look at feeding systems for each particular feed resource in each locality, because there is variation among efficiency and production particularly in dairy cattle within one locality. The feeding systems should match with genetic resources in each location and the feeding guidelines in each locality need to be further developed in order to be fully exploited by the farmers or end users. So I would like to make a strong recommendation that feeding guidelines need to be discussed in SE Asia with locally available resources for each species.
- Leng: I agree absolutely with the proviso that if there is significant deficiency of something which might turn the whole system round, that the potential for importation, or for the encouragement of the missing element to be grown to overcome that deficiency should be recognised.
- Qureshi: This point comes out very clearly during this morning's discussion, that one should have feeding systems suited for production and even production of feeds or forages should be integrated according to the requirements of the production systems.
- Thomas: Werner. You know that the two tree legumes that have been most worked with are *Leucaena* and *Gliricidia*, and you know well the problems with psyllids in this region. You mentioned this new work to look at more accessions of *Leucaena*. In the last 10 years there has been a tremendous emphasis on collecting a wider range of tree genera by different institutions. Are you thinking to diversify away from *Leucaena* and *Gliricidia*?
- Stur: We are certainly very interested in these other species and we are in the process of trying to get a collection of these together with the view of evaluating them together with national partners in the region for particular systems where they may fit. We are not fixed on any particular genera. The reason I mentioned *Leucaena* was just because this was something that was going to be financed by ACIAR and is a big effort bringing OFI, University of Hawaii, University of Queensland and so on, together and we have agreed to co-ordinate some of their evaluations in the region, but this is not going to be the only one.
- Vo-Tong Xuan: (To Stur) Especially in central Vietnam we have large open access areas where there is no management system, and farmers usually graze

and overgraze large ruminants. I don't know whether in your coming programme there will be any objective to address this problem—to select the right kind of forage that can be adapted to the system.

Stur: In fact there is one of the evaluation sites in Vietnam in, I believe, the area you are talking about. It was one that the Vietnamese Ministry of Agriculture was very interested in developing. As a project we are trying to respond to what the countries' priorities are and what the countries want. One of the things we are trying to work out during the next year with Vietnamese colleagues is how this resource is going to be utilised in the long-term, and see what opportunities there may be for forage. But I do think there are other opportunities to improve the feed resource through supplementation.

Vo-Tong Xuan: (To Leng) I agree that we have to look for alternative sources for feeding our animals in the long run. Should we adapt to by-product farming systems or can we first suggest some of the potential sources of by-products and from there encourage farmers adoption of these plants into their systems? For instance, should we give priorities to sources like the by-product of banana? Farmers usually just chop banana trunk, and mix it with the rice bran and feed to the pigs. Do you think we should go in this direction to improve these fibrous materials to improve the quality of the feed?

And my second question is that you mentioned sugar-cane feeding. This is really very interesting, especially in the mountain areas where sugar-cane be adapted to the hilly parts, but still there are debates about whether we use it for pigs or to produce the sugar?

Leng: If we have a by-product, we ought to use it as efficiently as possible. For example, one by-product that is universally available in the world is brewers' grains but we feed all the brewers' grains to a few animals as a total feed and yet this is a very high quality protein for ruminants. If we dried it and distributed it widely, as a separate supplement, we would make much better use of it. As far as the pseudo-stem of banana goes (which is 65% digestible), potentially on the work that has been done in China, we should be able to get a kilogram a day gain by appropriate supplementation. So that the research we have to do is find out how to get to that kilogram of gain economically, and not just the short-term economics, but long term, keeping in mind there are going to be changes in the cost of fuel in the future and that fertiliser prices are tied to fuel and will also go up.

Steane: Regarding use of local resources, I do see a major area for work looking at scavenging level combined with use of local resources versus importation which is the developed country syndrome being adopted by many countries of Asia particularly for pigs and poultry. We see this massive entrepreneurial-type of development. We must look at the structure of these industries. Vietnam and China have peasant-based livestock and pig production systems which we should aim to exploit. The use of banana trunks is a classic example of the way they do it.

I would like to address a comment to IRRI, now I am here: the new rice variety has been developed for about 30% increase in yield of

rice, but no one has asked the questions about the nutritional value or the yield of the straw. This has massive implications for this region.

We really need to look at the traditional systems and how we optimise them using the breeds that already exist and we must remember that the pig is an omnivore and can quite easily graze. Also, can I emphasise the environmental concern that Ron Leng expressed because I think that is going to be the major limitation to livestock production.

Devendra: I want to pick up this debate on the balance between fundamental research and on-farm research. The root of the problem comes back, as I see it, to core project formulation. In many instances, there is a fundamental flaw in project formulation that does not allow the researches to get out to on-farm situations. With the fibrous crop residues, the need for on-farm application far outweighs the need for any more work on treatments or supplementation and the like. But, the system does not allow or help researchers in formulating on-farm work and that is something to address, hopefully all the way down to post-production systems.

My second comment to Dr Stur is on forages. In a regional sense, when I look back 20–30 years, the programmes have been largely focused from a very strong agronomic thrust. Seed production has been implied but somehow has been in the hands of somebody else. The bulk of the work has been on pastures, evaluation of cultivars, screening and so on, but one does not get, over time, the impression that it is focused within production systems. In other words, are we addressing the real needs of drought-prone situations, what are the opportunities within prevailing specific ecosystem targets, forages, biomass to be increased within a balance of grasses versus legumes etc? These are some difficulties and I don't know whether in many of these programmes livestock and the utilisation of forages have been included. Perhaps we can provide this focus in the future?

Stur: I think it is very difficult analysing why things have not been successful in the past, and I agree with your first comment. I think it is really adoption of forages which we already have in hand that is needed first and I think that this is where the thrust of our programme goes. We expect, however, that by doing on-farm work we will identify research problems which will fit back into the research phase. We see this as a linkage.

Thinking of production systems. One problem one always has when one looks at species evaluation, particularly in the early phase on a station, when you look at many species unless you identify the production system in which it is supposed to go and the particular need that it is supposed to fill, people tend to go for ones that produce most. But once it comes out into the production system, you find that the seed production doesn't work; it may require too much nutrients, management etc, and the whole thing sort of collapses and disappears. It is a very important point and I agree with you that we have to identify the production systems and define very clearly what we really want out of a forage or any other technology we want to feed into be successful.

# Major initiatives and contributions of FAO/APHCA to the development of livestock agriculture in the Asia-Pacific region

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## Abstract

The paper describes the major initiatives and contribution of FAO/APHCA concerning the development of livestock in the Asia-Pacific region. The main areas are animal health, animal production, biotechnology application to animal production and health and training and information exchange programmes. In addition, attention is drawn to a number of other professional and technical organisations involved with livestock research and development in the Asia-Pacific region.

## Introduction

The Food and Agriculture Organization of the United Nations (FAO) is an international body whose functions are among others: i) to collect, analyse, interpret and disseminate information relating to nutrition, food and agriculture, ii) to promote international actions with respect to scientific, technological, social and economic research to nutrition, food and agriculture, and iii) to provide policy advice and technical assistance to member nations.

Its regional office for Asia and the Pacific (RAP) is located in Bangkok, Thailand, and its livestock section in RAP is staffed with two professional officers, one technical assistant, two secretaries and one temporal assistant. The FAO Regional Animal Production and Health Commission for Asia and the Pacific, commonly known by its acronym, APHCA, is the body under which member countries get together, discuss, identify and implement the livestock activities of common interest in a collaborative manner. The secretariat is located in the FAO office, Bangkok which provides the Commission with logistic and technical services.

In this paper, the past, present and future livestock activities of FAO in the region with particular reference to those of APHCA will be described. In doing so, the possible areas for future collaborative actions with the newly-created International Livestock Research Institute (ILRI) will be suggested and discussed.

## The Asia-Pacific region and its livestock

This region is quite unique in terms of diversity of size and population, and the degree of its economic development of each member state. China, the world's most populous nation with 1.2 billion people in 1994, is at one extreme and several South Pacific island countries whose population is less than 100,000 are at the other. The agro-ecological conditions of the region are diverse, ranging from extreme cold with no rain (Mongolia and northern China) to the humid tropics of South-East Asia and the Pacific, and the semi-arid tropics/subtropics of south Asia. In terms of economic development, the Asia-Pacific Region includes three industrialised nations (Australia, New Zealand and Japan) and, seven of the

so-called least developed countries (LDC). The other countries fall between these two extremes.

The Asia-Pacific region accounted for 56% of the world's population in 1994. In terms of agricultural population, the region stands as high as 72% of the world total. However, this region comprises only 30% of the world's arable land. It is now almost impossible to develop new arable land without further destruction of forest land or without any environmental degradation. Indeed per caput availability of agricultural land has been steadily decreasing in the recent past. Compared to the world figure of 0.58 ha per agricultural population, in 1993 the Asia-Pacific region had the smallest unit land area at 0.26 ha per agriculture population.

In the livestock sector, the intensification and commercialisation of animal production has been the general trend in both developing and industrialised countries, particularly for pig and poultry operations. In developing countries, however, a majority of large ruminants (cattle and buffaloes) and small ruminants (sheep and goats) are still in the hands of rural small farmers. An essential role of large ruminants as major generators of farm/rural energy and providers of fertiliser is still, and will continue to be, important in many countries of the region. Thus, livestock are highly associated with crop production, and should be considered as one of the essential components when such topics as rural poverty alleviation, environmental degradation, food security or sustainable agriculture are considered.

The three industrialised nations in the region have unique livestock features. Australia and New Zealand have been world leaders in the export of meat and milk, while Japan has been the world's largest meat importer (over US\$ 7 billion in 1993).

During the last decade, the region has achieved remarkable progress in the livestock sector. The average annual growth rates of meat, milk and egg production during 1983–93 were 6.3%, 4.4% and 7.7%, respectively. These figures become even more impressive, (7.3%, 5.2% and 9.4%, respectively) when the three industrialised countries are excluded from the calculation. The rates are all much higher than the world average. However, when the progress is considered in terms of per caput availability of these livestock products, the region is still much lower than the world average. Therefore, there is no complacency and the impressive progress in the past should be maintained or further expanded at least to the level of the world average by the turn of this century.

## **Livestock activities**

The policy strategies and subsequent field programmes in the region have been, and continue to be, to increase livestock production not through more animals but through higher productivity (i.e. more product output per animal). To this end, the unproductive animals are to be replaced progressively by improved varieties. Introduction of high-performance exotic breeds and their crosses with local breeds have been the most popular tactics in this regard, while the improvement of native breeds tended to be neglected in most developing countries. To express maximum production potential, animal husbandry operations with improved varieties require ample supply of quality feeds, constant veterinary care, and often continuing reliance on foreign suppliers for breeding stock replacement. In addition, post-production activities such as slaughter, product processing and marketing, pricing policies, livestock trade etc have been the subject of great concern. In Annex I, the list of the FAO/APHCA activities undertaken during the past five

years, and the future mid-term proposals (up to 1997) are presented. Obviously, many of the activities described will involve co-ordinated livestock research and survey as their major components and thus some of them may be suggested as major thrust areas for future collaboration with ILRI. These are listed below:

### **Animal health**

- Newcastle disease feed vaccine
- Gumboro disease vaccine and vaccination scheme
- Haemorrhagic septicaemia (H.S.) live vaccine
- Rinderpest: vaccine, diagnosis and surveillance
- Foot-and-mouth diseases (FMD): vaccine, diagnosis and surveillance
- Disease free zone (survey)
- Animal quarantine (survey)

### **Animal production**

- Buffalo research networks
- Rural poultry production system
- Silvi-aquaculture with livestock
- Domestic animal genetic diversity
- Conservation of animal genetic resources
- Livestock insurance (survey)

### **Biotechnology application to animal production and health**

- Monoclonal antibodies and ELISA for disease diagnosis
- RIA and ELISA for hormone assay
- *In-vitro/in-vivo* fermentation for better utilisation of feed resources

### **Training and information exchange programme**

- Regional workshop/training
- Exchange programme for farmers and scientists
- Publication of various technical documents/books
- Asian Livestock, monthly publication

Since the late 1980s, UNDP, a major financial contributor for FAO field activities, shifted its strategy from a "project" to a "programme" approach with special emphasis on sustainable production. Further, the new sub-programme classification for FAO livestock activities has been devised lately and is given in **Annex 2**. FAO is expected to operate the activities under the new livestock sub-programmes in 1996.

## **Regional and international organisations**

There are relatively small numbers of professional and technical organisations actively involved in livestock research and development in the Asia-Pacific Region.

### **Asian Veterinary Association (AVA)**

Established in the early 1970s, this association for veterinary professionals, dominated by university professors and researchers of government research institutes, holds its general assembly every 2–3 years. The last assembly was in Manila, the Philippines, in 1992 and the next one will be in Yokohama, Japan, in September 1995. Areas of research interest cover almost all aspects of animal health of concern in the region.

### **Asian-Australasian Animal Production Association (AAP)**

Established in the late 1970s, this association is also dominated by academicians. The association holds its general assembly once every two years. The last assembly was in Bali, Indonesia, in 1994 and the next will be held in Tokyo in 1996.

The main purpose of both the AVA and AAP has been the mutual familiarisation of members and their activities and information exchange. The two general assemblies have hardly any joint activities.

### **Asian Buffalo Association (ABA)**

This association was established in 1992. Its objectives are to:

- promote the exchange and dissemination of scientific and technical know-how and information in buffalo production and development
- enhance the contact among scientists and extension personnel concerned with buffalo production
- encourage the establishment of appropriate co-operative research and training programmes in accordance with identified national or regional, bilateral needs and priorities
- assist in the strengthening of research organisation and management capability of member institutions
- strengthen linkage between national, regional and international research centres and organisations, including universities, through involvement in jointly-planned research and training programmes.

The first Association Congress was organised in Khon Kaen, Thailand, in 1994. The Association published a "Directory of Scientists/Experts in Buffalo Research and Development" to promote communication among those concerned with buffalo research and development in Asia.

### **FAO supported regional networks**

Currently FAO/APHCA provides logistic and some financial support for the operation of the following regional networks:

- Asian Network on Animal Biotechnology

- Asia-Pacific Network on Animal Health Information
- Asian Network on Domestic Animal Diversity (under a Regional Trust Fund Project)

## **International Atomic Energy Agency (IAEA)**

FAO operates with the International Atomic Energy Agency (IAEA) in Vienna, a joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture. The joint division aims to promote the use of nuclear and related techniques in food and agriculture. In the division there is a sub-division on Animal Production and Health which has been exclusively involved in co-ordinated livestock research activities on a regional basis. In the Asia-Pacific Region, the activities have been the promotion of the use of ELISA technologies for application in both animal production (hormone assay) and animal health (diagnosis and surveillance of FMD, rinderpest and other infectious diseases of economic importance). Support for its Co-ordinated Research Programme is provided through the IAEA Technical Co-operation Project (TCP) which is granted to the institute, and the Research Contract which is granted to individual researchers. FAO/IAEA technical officers stationed in Vienna visit the TCP-holding institutes and the research contract holders on the regular basis. They also organise the regional meetings to discuss the progress of the programme and make closer contact among research contract holders. Three major components of the programme are fielding of experts, training and provision of equipment. Usually one programme continues for five years.

Although the monetary support is nominal and never exceeds US\$ 50,000 per TCP for one 5-year research programme, the FAO/IAEA co-ordinated research programme has been well-known to those scientists directly concerned in the corresponding field. The FAO/IAEA Programme seeks to reduce bureaucratic hurdles and the contract holders tend to enjoy more freedom in the use of granted money compared with projects operated by some other international agencies.

It is suggested that the rules and procedures of FAO/IAEA co-ordinated research programme can provide an example of ILRI's future *modus operandi* to implement the co-ordinated research activities on a regional basis.

## **Some suggestions to ILRI for future working arrangements and priority areas in the region**

With the current budgetary constraints in the wider UN system and in other international agencies, it may be difficult to foresee the establishment of a new ILRI subcentre in the Asia-Pacific Region. Thus, the livestock research activities which should also include those of "survey"—and "socio-economic"—type would be co-ordinated through the IAEA style-operations already described. The lead institution can be identified for each research subject and would be closely associated with collaborative institutes concerned with the subject in the region. When needed, a close linkage with advanced institutions in industrialised countries should be established. A research subject may be either narrowly defined (i.e. improvement of an H.S. vaccine) or those of umbrella type (i.e. poverty alleviation through livestock in arid lands of south Asia). Both "project" and "programme" approaches should be considered, the former more technical, science-oriented

research, and the latter more complicated, requiring an integrated systems approach with socio-economic inputs.

## **Conclusion**

It was really a most welcome decision for the newly created international research organisation, ILRI, to widen its geographical mandate and extend its activities beyond Africa to cover the Asia-Pacific region. All national livestock research institutes and international and bilateral agencies concerned with livestock development in Asia and the Pacific will be eager to co-operate with ILRI's initiatives for new livestock research and development in the region. Definitely, the FAO Regional Office and APHCA await collaborative activities in the near future.

It is, in this respect, hoped that ILRI can pay due attention and allocate an adequate share of its resources to the Asia-Pacific Region where one can find almost one-fourth of the world's agricultural population—many of them marginal, rural subsistence farmers—and a vast wealth of livestock resources to help raise the living standard of these rural people in the foreseeable future.

## **List of FAO/APHCA activities (From 1990 to 1997)**

### **1. Animal health**

- 1.1. Infectious and parasitic diseases
  - 1.1.1. Poultry diseases
  - 1.1.2. Haemorrhagic septicaemia
  - 1.1.3. Foot-and-mouth disease
  - 1.1.4. Rinderpest
- 1.2. Veterinary services
  - 1.2.1. Vaccine bank
  - 1.2.2. Disease-free zones, intra-regional trade
  - 1.2.3. Animal quarantine and import/export regulations
  - 1.2.4. Quarantine station management
  - 1.2.5. Veterinary public health
  - 1.2.6. Veterinary drug registration and certification
  - 1.2.7. Privatisation of veterinary services

### **2. Animal production**

- 2.1.1. Buffalo development
- 2.1.2. Poultry production
- 2.1.3. Small ruminant development
- 2.1.4. Pig production
- 2.2. Livestock resources
  - 2.2.1. Artificial insemination and breeding
  - 2.2.2. Frozen semen bank
  - 2.2.3. Conservation of animal genetic resources
- 2.3. Feed resources
  - 2.3.1. Studies on feeds and feeding of livestock and poultry
  - 2.3.2. Utilisation of straw and agro-industrial by-products
  - 2.3.3. Community forestry in support of animal production
  - 2.2.4. Livestock statistics
- 2.4. Promotion of livestock insurance programme
- 2.5. Animal welfare

### **3. Meat development**

- 3.1. Meat hygiene

- 3.2. Abattoir management
- 3.3. Meat marketing and trade

#### **4. Dairy development**

- 4.1. Support to dairy co-operatives
- 4.2. Liaison with other international and bilateral organisations
- 4.3. Marketing and trade of milk and milk products

#### **5. Biotechnology network in animal production and health in Asia**

#### **6. Technical co-operation among developing countries (TCDC) activities**

- 6.1. Exchange of experts/technicians among APHCA member countries
- 6.2. Exchange visit of farmers as TCDC
- 6.3. Practical attachment training programme
- 6.4. Women and livestock production in Asia

#### **7. Training programme and meetings**

- 7.1. Training programme and meetings in animal production
  - 7.1.1. Duck production
  - 7.1.2. Live animal markets and marketing system
  - 7.1.3. Semen production and quality control
- 7.2. Training programme and meeting in animal health
  - 7.2.1. Veterinary management development programme

#### **8. Information exchange programme**

- 8.1. Publication of *Asian Livestock*
- 8.2. Animal disease information service
- 8.3. APHCA information exchange unit

### FAO sub-programme classification (Livestock)

Present

From 1996

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|                                    |                                             |
|------------------------------------|---------------------------------------------|
| 1. Feed resources                  | 9. Information systems, policy and planning |
| 2. Animal health<br>supply systems | 10. Peri-urban and intensive production and |
| 3. Genetic resources               | 11. Mixed farming systems                   |
| 4. Dairy development               | 12. Pastoral and extensive grazing systems  |
| 5. Meat development                | 13. Domestic animal genetic diversity       |
| 6. Livestock production            | 14. Transboundary animal diseases           |
| 7. Field programme support         |                                             |
| 8. Programme management            |                                             |

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## Discussion following Dr Sasaki's paper

- Qureshi: I would like to draw attention to the Animal Production and Health Commission for Asia and the Pacific regions. It involves the directors of veterinary services and livestock development. They meet every year and discuss various questions including livestock production and the animal development situation in the whole region. Some of their priorities listed for research may be applicable here. For instance, the priorities are given for buffalo research.
- Hayakawa: I am most interested in your [Sasaki's] last comment [about ILRI contributing financially]. What sort of allocation do you expect for the new research centre this year? What is the scale?
- Sasaki: In Dr Fitzhugh's opening speech, he wished to have the input from the region to decide the priorities, strategies and the financial contribution. We didn't previously have a lot of input from ILCA and ILRAD, because those two international institutes were mainly involved in African countries, but as of January this year, they changed the mandate, and they have to come to our region, so I think we do have justifiable allocation from their resources to develop livestock in Asian countries.
- Diwyanto: You mention that meat production increased by 5% per year, but the population of cattle increased only 1% per year. Is that because of the improvement of productivity of the cattle or because of the imported feedlot cattle from outside the region?
- Sasaki: When we say "the population", population means the number of animals on a particular day, and when we say "production", production means how many animals were killed during that year. There is more turnover without increasing cattle population. We never encourage any more to increase population. We encourage all member countries to improve productivity. For instance, if you think of meat production instead of keeping animals say .seven years you keep them five years then definitely the population is the same but you can increase production.
- Vo-Tong Xuan: There seems to be a relationship between the scale of the rice activity of IRRI and that of FAO. Now with ILRI coming in to Asia, do you think there is some threat to your animal production programme with FAO?
- Sasaki: We have to surrender some parts to ILRI. I think we are not concerned about this. The contribution from ILRI may be small at the early stage. Dr Fitzhugh never mentioned it in monetary terms, and I am not sure of the organisational things, how ILRI is going to establish a subregional centre of their own here. I thought, in the next two or three years, the main activities with ILRI should be of the co-operative type: co-operation with NARS, or bilateral research or through the CG system, of course.
- Wanapat: I would like to see him (Sasaki) elaborate more on how you would envisage and anticipate the activities in working with ILRI in this region in order to fully carry out the activities in complementary fashion as partners.

- Sasaki: I think I see the development of strategy and programme as an important aspect. There should not be conflict between the two agencies and we will try to co-operate and support whatever you propose to ILRI.
- Qureshi: There is one area of co-operation which is already developing and may be David Steane you want to comment on that.
- Steane: In terms of the genetic resources side, I am delighted that ILRI is coming into the region. We have for many years been co-operating when we first did a global survey. ILCA as it was then, and with Hank Fitzhugh as the Research Director, helped us tremendously with all the African data. Since that date we have developed through the expert consultation (in which Hank also took part in 1992). We have organised a system where FAO essentially will take the overall co-ordination role for genetic resources and the research side of it will very clearly be that of ILRI. I welcome the inputs that I hope we will see in Asia into the research, into the characterisation of breeds (because that's an area where we really lack a lot of information) and I certainly see us working very closely together. So I am delighted to see them here and I look forward to it adding to the effort and operating in the research areas where FAO really does not have to operate. This allows us to do the co-ordination and the practical on the ground development work. I also have to back Sasaki in that I welcome their investment too.

# Effective utilisation and conservation of indigenous animal genetic resources: Development of the carabaos in the Philippines

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## Abstract

Effective utilisation of indigenous animal genetic resources is discussed with specific reference to experiences with research and development of the carabao in the Philippines. The paper puts into perspective the presence of genetic diversity, recent developments in breed improvement, future challenges to develop crossbred animals for smallholders and the importance of conservation. Data are given on the distribution of an estimated population of about 18 million swamp buffaloes in South-East Asia. Within this group, all the countries in Indo-China together with Indonesia recorded average annual population growth rates of between 1.9–3.9%, whereas Malaysia, the Philippines and Thailand had between -1.7 and 3.3% decreases. Their value, especially to draft and beef production, is indicated. The Philippine carabao development programme involves strengthening the gene pool, upgrading carabao for milk and meat, enterprise development, and research and development activities. Major researchable issues are breeding and genetics, feeding and nutrition, reproduction, animal health, socio-economic aspects, technology delivery and policy matters. The constraints to research are technical manpower capability, sustained funding, information flow, systems orientation, failure to translate the efforts and programme continuity. The research and development efforts in the Philippines, and the implications of the activities to the South-East Asian region and elsewhere are emphasised.

## Introduction

The entire human community has been alarmed by the growing population, increasing at a rate perceived to be faster than our ability to produce food out of our finite resources. For many years, however, we have been witness to the significant increases in yields of our major crops and livestock at a rate that outpaced the present human requirements. These significant developments have been made possible by our understanding of the underlying principles of breeding and genetics, which allowed us to manipulate the genetic resources endowed by nature.

Knowledge of the magnitude of the available genetic resources in the world leads to the understanding of the rate at which we lose them. Concerns have been raised by many sectors on the Opportunity which may be lost to the future generations by denying them access to these natural endowments.

Conservation of genetic diversity in livestock has also caught the attention of many international bodies and institutions. Measures to identify what species and breeds remain, and conserve those perceived to be of value is a major current undertaking. Efforts to utilise and conserve the water buffalo (carabao) in the Philippines is an example.

# Utilisation and conservation of animal genetic resources

## Genetic diversity—nature's way

We are gifted in this natural world with the miracles of great biological diversity. Biological species have undergone natural selection processes for millions of years and this is the very foundation of the environment in which we now live. This we cannot replicate.

Through time, competition for limited resources and natural selection among competing species for survival and reproduction have shaped the change in genetic variation. Species either become adapted or are lost to specific environments.

In the quest of mankind for survival during the past 10,000 to 12,000 years, we have learned to domesticate plants and animals that would provide us with the basic requirements for clothing, food, work and recreation. In the process, the use of species in the local environment is followed by genetic change that occurs from unconscious activities involving selected domesticated species of plant and animals that are carried to different environments through human migration. The genetic change involved is rather slow and natural. As man continues to migrate, so do his domesticated species. These processes create locally adapted strains within species in many different locations of the earth. Over thousands of years, the local breeds become adapted to their environment and are form the indigenous breeds of those environments with which they have had a long association (Hodges 1992b).

## Recent developments—cause for alarm

The slow pace of genetic change in domestic animals over those 10 millennia is contrasted by the rapid genetic change in the last 250 years. In fact, the rate of genetic change in the developed world can be considered exponential. This has been made possible by the quantum leap in understanding and control of the nature of genetic variation, and the ability and economic pressure to apply the technology of change on a global scale.

Present day animal breeding techniques, such as cross breeding and breed replacements, are used to increase output of animal products and the productivity of animals. In fact, the thrust of all animal genetic activity is to obtain higher quantity, better quality and improve biological and economic efficiency. This activity threatens the species that are not economical. The global consequence of this decay in genetic diversity has been extensively discussed in many international fora (Barker 1992; Hodges 1992a; Hodges 1992b; Hodges 1993).

As man's activities of this nature continue unchecked, the threat to extensive loss of biodiversity grows. The loss is irrevocable and the process of loss is accelerating. The loss in genetic diversity limits evolution and development in agriculture. It narrows and eliminates options for the future.

Today, 95% of human food comes from just 30 kinds of plant and 10 major domesticated species of animals. If a major epidemic struck any of the cereal crops such as wheat, rice and maize, there would be death by famine on a cataclysmic scale. The same may be said about poultry and livestock.

In Europe, traditional breeds of cattle, sheep, pigs and horses disappeared as a result of breed substitution motivated by economic considerations. In November 1993, the first World Watch List for Domestic Animal Diversity (WWL-DAD)

estimated that 390 breeds, representing 28% of those breeds so far identified, are at risk.

## Animal genetic resources and future challenges

The estimate of the global number of breeds from the 10 main domesticated animal species is in the region of 3000 to 4000. In 1992, only 2054 breeds had been identified. The number of breeds per geographical region has been reported by FAO (Ruane 1992), and is given in Table 1. Interestingly, large numbers of these breeds are found in Asia.

There are only 405 breeds with complete information on population and/or production traits representing 19.7% of the number identified (Table 2). It is possible that some of the unidentified breeds may disappear before they are fully characterised.

In a recent report, Steane (1994), described some 2719 breeds from FAO data and a global based survey compiled in the global data bank. Of these, only 1433 have available population data.

**Table 1.** *Number of breeds per geographical region in the FAO Global Animal Genetic Data Bank (1992).*

| Species  | Asia | Africa | Former USSR | North and Central America | Latin America | Oceania | Total |
|----------|------|--------|-------------|---------------------------|---------------|---------|-------|
| Buffalo  | 63   | 8      | 1           | 1                         | 2             | 0       | 75    |
| Cattle   | 200  | 173    | 62          | 67                        | 45            | 21      | 568   |
| Sheep    | 231  | 432    | 135         | 48                        | 17            | 39      | 603   |
| Goat     | 147  | 59     | 20          | 12                        | 11            | 6       | 255   |
| Pig      | 142  | 8      | 35          | 35                        | 17            | 6       | 243   |
| Horse    | 88   | 35     | 59          | 41                        | 22            | 2       | 247   |
| Ass      | 22   | 16     | 15          | 5                         | 5             | 0       | 63    |
| Total    | 893  | 432    | 327         | 209                       | 119           | 74      | 2054  |
| Per cent | 43.4 | 21.0   | 18.9        | 10.2                      | 5.7           | 3.6     | 100   |

**Table 2.** *Number of breeds in the FAO Global Animal Genetic Data Bank for which there is some information on population size and/or production traits.*

| Species  | Asia | Africa | Former USSR | North and Central America | Latin America | Oceania | Total | %  |
|----------|------|--------|-------------|---------------------------|---------------|---------|-------|----|
| Buffalo  | 1    | 1      | 1           | 0                         | 0             | 0       | 3     | 4  |
| Cattle   | 36   | 68     | 35          | 2                         | 12            | 0       | 126   | 22 |
| Sheep    | 80   | 18     | 51          | 5                         | 5             | 2       | 161   | 27 |
| Goat     | 25   | 11     | 7           | 1                         | 2             | 2       | 38    | 19 |
| Pig      | 12   | 1      | 21          | 1                         | 2             | 0       | 37    | 15 |
| Horse    | 0    | 0      | 30          | 0                         | 0             | 0       | 30    | 12 |
| Ass      | 0    | 0      | 0           | 0                         | 0             | 0       | 0     | 0  |
| Total    | 154  | 69     | 148         | 9                         | 21            | 4       | 204   |    |
| Per cent | 17   | 16     | 45          | 4                         | 18            | 5       | 20    |    |

The percentages are of the totals presented in Table 1.

As the demand for products of animal origin increases, the pressure to produce meat, milk, wool and hide becomes a challenge in the future. While much can be done to improve productivity by improving management techniques, the ultimate productive capacity of animals is controlled by genetics. In fact, animal performance and health are affected by one or more of the 10,000 or so genes in the genomes of each of the livestock species. The availability of a rich genetic resource would permit geneticists to combine these genes in new ways to develop new breeds of farm animals with greater fitness and higher productivity.

Specific genes influence resistance to disease, while others are responsible for growth, egg production, milk production, meat quality and fertility. Almost invariably, any given animal or breed does not carry all of the most desirable genes for a given environment—those endowing disease resistance, tolerance to heat, feed efficiency, high growth rate etc. The greatest challenge to geneticists and breeders would be the ability to integrate into one individual gene combinations that collectively provide optimum performance. From this perspective, it is crucial to halt the rapid loss of important genetic materials amongst farm animals.

The awesome developments in biotechnology in recent years have opened new horizons in livestock production. For example, transgenic animals have been developed to produce specific products such as increased leanness in carcass, special proteins in the milk, modified composition of wool, increased resistance to specific diseases etc. In essence, the availability of genetic materials dictates the breadth by which future animals can be tailored. It highlights the need to identify and conserve what nature has given us in the form of valuable genetic resources.

## **Conserving animal genetic resources**

The existence of genetic and phenotypic variations of the characters of importance to man has been used as a basis for conservation and breeding plans pertaining to genetic improvement. The conservation strategies, as discussed at various fora such as the FAO/UNEP consultations (1983,1984,1989,1992) and many other international meetings, should be applied only to economically, aesthetically important rare and endangered livestock and poultry species. This conservation is important to maintain genetic variability between populations within each domestic species.

Several options are available at the moment on methods of conserving genetic materials. Maintenance of live animals, *in situ* conservation, is presently being carried out for cattle, sheep, goats and poultry. This method is costly in terms of maintenance and management as it involves provision of the natural environment to a considerable number of live animals. There is also a possibility that such populations, if relatively small, may suffer from inbreeding and genetic drift (Acharya 1992). This method, however, may be the simplest approach at the moment since there is still a need to develop *ex-situ* cryopreservation methods for many species. It also provides opportunities for future characterisation of animals where this has not yet been done. Also, adjustment to environment can further be expected in live animals, e.g. in the case of exposure to mutated viral diseases. This can not take place in cryopreserved materials.

The *ex-situ* method involves cryopreservation of sperm cells, oocytes, or embryos. Other options in the future will consider cryopreservation of chromosomes, gene clusters and genes (Mukherjee 1992). The advantages of this method is the

minimal cost of maintenance relative to the *in situ* method. Since the genetic materials are preserved, genetic change is not expected as might be anticipated through selection, adaptation or gene loss in live animals. These methods of *ex situ* preservation, however, are technically demanding. In fact, even to date, there are some animal species whose semen can not be cryopreserved without significant damage. Because of this, the risk to these species and breeds appears to be high and such risks increase with length of storage due to a variety of human related factors. Additionally, of course, there is no expected genetic gain through this sort of preservation due to the absence of selection in this case.

## South-East Asian (SEA) water buffalo resources

Buffalo belong to the class Mammalia, subclass Eutheria, order Ungulata and the family Bovidae. Bovinae is a tribe of Bovidae and contains three genera: *Bos*, *Bubalina* and *Syncerina*. Domestic buffalo belong to *Bubalina* while the African buffalo belong to *Syncerina*. There are two major types of domestic buffalo, namely the river buffalo of the Indian subcontinent and the swamp buffalo of the south Asian region.

The water buffalo is indeed an Asian animal. Seen from the population distribution over the past several years, about 96% of the world buffalo population is found in Asia (Table 3). In fact, 63 of the 75 identified breeds of water buffalo in the world are found in this region. Fortunately, only one of those, the Tamaraw of the Philippines, is believed to be endangered.

**Table 3.** World buffalo population ('000).

| Region        | 1993    | %     |
|---------------|---------|-------|
| Africa        | 3036    | 2.0   |
| North America | 9       | 0.006 |
| South America | 1551    | 1.05  |
| Asia          | 142,213 | 96.40 |
| Europe        | 311     | 0.21  |
| Former USSR   | 4000    | 0.27  |
| World         | 148,876 | 100   |

By 1992 information on population size and production traits for only three (4%) of the identified breeds of buffalo. In fact the breeds of swamp buffalo in the Asian region are not yet well recognised. It was shown, however, that there are significant genetic distances among the swamp buffalo population of SEA (Mukherjee et al 1991). The noted differences among some populations are of the same order of magnitude as those reported in well recognised and long-standing breeds of livestock in the developed world (Figure 1).

**Figure 1.** Dendrogram of genetic relationships (genetic distances) among 10 populations of swamp buffaloes taken from the Philippines (Musuan), Indonesia (Bogor, Ujung Pandan, Sarawak and Medan), Malaysia (Sabah and Haadyai) and Thailand (Cheng Mai and Surin).

In the SEA region, the countries with water buffaloes can be grouped into those with increasing buffalo populations and those with negative growth (Table 4).

**Table 4.** *Water buffalo populations in SEA.*

| Country*        | 1993 ('000) | Average annual growth rate (%)** |
|-----------------|-------------|----------------------------------|
| Positive growth |             |                                  |
| Cambodia        | 804         | 3.9                              |
| Indonesia       | 3452        | 2.4                              |
| Laos            | 1167        | 2.4                              |
| Myanmar         | 2110        | 0.0                              |
| Vietnam         | 2956        | 1.9                              |
| Negative growth |             |                                  |
| Malaysia        | 186         | -2.5                             |
| The Philippines | 2561        | -1.7                             |
| Thailand        | 4747        | -3.3                             |
| SEA             | 17,983      | 0.53                             |
| World           | 148,876     | 1.3                              |

\* countries with insignificant numbers are not included.

\*\* 1983–93 period.

Source: FAO (1994).

While most of the SEA countries with significant numbers of buffalo had average annual population growth rate of 2.5%, three countries, namely, Malaysia, the Philippines and Thailand, had average annual population changes of -2.14% during the last 10 years. The trend noted in these three countries reflects the high extraction rate from the population caused by one, or a combination of, factor(s) such as decreasing usage of buffaloes as draft animal due to farm mechanisation and increased demand and consumption of buffalo meat related to the increasing human population. Water buffalo contribute about 50% of the beef in countries such as Thailand and the Philippines. Their milk contribution is rather small.

Water buffaloes in SEA are generally the swamp type (chromosome 2n=48) and are utilised as draft animals in most farming systems. This pattern of usage is readily explained by the fact that Asian farmers are essentially small landholders, owning 1 to 2 hectares of land. It is economical and logical for farmers to depend on water buffalo as their source of draft power. Buffaloes, therefore, are raised as part of the small farming system rather than as a specialised system.

The changing face of Asian farming is characterised by the increased use of small tractors for land tillage. This development is very prominent in irrigated areas and in lowland rice farming communities and has, to some extent, influenced the pattern of carabao use in these communities. Over the next 30 years, however, despite the mechanisation of small farms in SEA, it is perceived that the large buffalo resource in this region will still be important as draft animals. There is a need, however, to redefine the future role of this rich animal resource in Asia in the long term.

# Utilisation and conservation of carabao in the Philippines

## Historical perspective

Carabaos are major partners in the rural farming families in the Philippines. This is clearly shown by the fact that 99.9% of the 2.6 million carabaos belong to small-scale farmers. For many years, this animal has been the major source of draft power in all their farming activities, irrespective of agro-ecological zone. Two major issues have alarmed the industry, notably the fast decline of its population during the last 15–20 years and concomitant decay in its quality.

Organised research on water buffalo in the Philippines was started in 1975 when the Philippine Council for Agriculture and Forestry Resources Research and Development (PCARRD) created a separate commodity research team to address the concerns of the carabao sector. The introduction of riverine (chromosome  $2n=50$ ) buffaloes from India occurred as early as the 1930s and continued into the 1950s. Due to the absence of an organised breeding programme, however, the utilisation of such germplasm was not orderly and thus the impact is difficult to assess.

Assistance from the United Nations Development Programme (UNDP) was received in 1981 under the Project "Strengthening of the Philippine Carabao Research and Development Center", PHI 78/017. The project was implemented from 1982 to 1987 by the Food and Agriculture Organization of the United Nations (FAO) with PCARRD serving as the co-ordinating agency. The main objective of such assistance was to strengthen the institutional capabilities of the Philippines to carry out research and development of the carabao. Such assistance resulted in the establishment of facilities and strengthening of manpower capability at six stations involved in the project in the different host institutions in the country namely University of the Philippines at Los Banos (UPLB), Central Luzon State University (CLSU), Cagayan State University (CSU), Central Mindanao University (CMU), Ubay Stock Farm (USF) and La Carlota Stock Farm (LCSF).

Phase II of the project, PHI 85/006, was carried out from 1987 to 1992. It was a follow-through of the technology development phase, to enhance government institutional capacities for effective dissemination of suitable technologies to as large a number of target recipients possible.

One of the main foci of research during the period of assistance was the introduction of fresh germplasm of riverine buffalo. Such material was used to cross the native carabaos and to document the performance of the resulting crossbreds in terms of various production parameters and fertility. Introduction of the dairy breed into the swamp buffalo populations in the co-operating villages resulted in the development of crossbreds with a high capacity to produce meat and milk without detrimental effects on their draft ability. These crossbred animals have been highly accepted by the farmers. The acceptability is largely due to the observed advantage for growth and milk, allowing the farmers to generate additional income almost equivalent in magnitude to that normally derived from crop farming. Several communities have now produced substantial numbers of these animals, and in some areas farmers are organised into associations and co-operatives for this purpose.

One year before the termination of the UNDP/FAO assistance, the government of the Philippines took steps to institutionalise the Carabao Development Programme,

taking into account the momentum gained from the project. Thus, the "Philippine Carabao Act of 1992", R.A. 7307, created the Philippine Carabao Center (PCC). In mid-1993, PCC operated as an agency of the Department of Agriculture. PCC's mandate is to conserve, propagate and promote carabao as a source of draft animal power, meat, milk and hide to benefit rural farmers.

In structure, PCC is a network of 13 centres, each being responsible for at least one political region in the country. This network of centres implements the Carabao Development Programme.

## **Philippine Carabao Development Programme**

In the medium term, covering the period 1993–98, the PCC's task is to implement the Carabao Development Programme as a component of the Medium Term Livestock Development (MTLDP), a sub-programme under the Medium Term Agriculture Development Programme (MTADP) of the Department of Agriculture. MTADP features the Key Production Area (KPA) approach, focusing development assistance in key areas where potential for increasing productivity is likely to succeed. While concentrating on the KPA for livestock, MTLDP seeks to lay the foundation for more productive livestock development. Central to this is the introduction of superior genetic materials to upgrade the production potential of the local stocks.

The Carabao Development Programme is indeed dovetailed with the National Medium Term Development Programme (MTDP) of the national government. In essence, the programme seeks to address poverty alleviation, employment generation and people's empowerment. In line with these goals, the programme seeks to develop the carabaos as a means by which the millions of rural impoverished families will have access to increased income, better nutrition and improved general well-being.

The Carabao Development Programme has four closely interrelated components, namely, a) strengthening gene pools, b) wide-scale upgrading, c) enterprise development and d) research and development. The programme demonstrates, in a way, the utilisation and conservation of water buffalo in the Philippines. The main end-point is the development of a carabao-based enterprise with a community resource base approach or, as some would term it, farming systems approach. The strategy is to improve the genetic potential of the carabaos to produce more milk and meat without disregard to its value as draft animal. Development of specialised buffalo-based, dairy enterprise or meat production or their combination may also take place. The enterprise development seeks to enable the farmers to raise carabaos to increase farm income, either from the added production of milk and/or meat or the improved role of draft animals. The programme relies on community organisation as a medium by which wider rural development can take place, thus promoting the development of co-operatives. This will facilitate the transfer of technologies, enable the farmers access to decision making and resources, and would enhance the marketing of produce.

### **Strengthening of the gene pool**

This element of the programme seeks to strengthen the efforts of the national government to select the best Philippine Swamp buffalo for future propagation, utilisation and conservation. This involves selection of the best animals from among the national population of carabaos and concentrating these in the PC centre

to constitute the elite herd. In effect, the effort will develop an open nucleus from which the best breeding swamp buffaloes may be obtained in the future (Figure 2). The establishment procedure of this Philippine Carabao Gene Pool (PCGP) is described in detail in Appendix 1.

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**Figure 2.** *Diagram showing several ways of conserving Philippine carabao germplasm.*

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The establishment of the PCGP is a form of conservation of the indigenous genetic material for future breeding purposes. Whilst the elite herd will be centrally raised at the PCGP, there are also dispersed populations all over the country in all the PC centres. There are 13 centres, of which five are in Luzon, four are in the Visayas and four are in Mindanao. The selected animals in the PC centre represent 10–20% of the centre's total herd and would serve as the source of elite animals for the PCGP. Selection of outstanding swamp buffaloes in the communities is a continuing activity, resulting in selection of carabaos with higher genetic potential, and as such strengthen the open nucleus over time.

Another feature of our genetic conservation programme is the use of small islands where migration of animals by land is not possible. In practice, the programme has identified the Fuga Island in the north and Basilan Island in the south, where swamp buffaloes are also raised. These islands are not to receive any introduction of the riverine breed at all. In effect, these initiatives will provide adequate allowance for the propagation of selected, pure swamp buffaloes to complement the on-going crossbreeding efforts.

A similar effort shall also be made for the riverine buffaloes. Since the population of the Murrah buffaloes in the Philippines is insignificant and to a large extent either highly inbred or diluted with swamp blood, the selection of outstanding riverine animals from the local population will be very limited. The programme calls for importation of selected animals, semen and embryos of the Murrah breed, the best of which shall form the elite herd of riverine buffaloes. The elite herd of riverine animals shall serve as a source of genetic materials for wide-scale, crossbreeding programmes and future genetic improvement for milk and meat.

The national gene pools for the Philippine carabao and riverine buffaloes are supported by facilities to allow collection and storage of semen. Techniques for embryo collection *in vivo* and embryo production *in vitro* are also being refined to permit embryo cryopreservation in the coming years. These embryos would constitute the *ex-situ* conservation of buffalo genetic materials in the country.

### **Upgrading for milk and meat**

This project component draws heavily on the information generated from the introduction of riverine buffaloes into the native carabao population. As a strategy in the MTLDP, the Key Livestock Production Area (KLPA) approach allows us to concentrate our efforts and assistance to specified communities where success is most likely. In matters where milk is to be the expected item for market, it is therefore important to site the production base closer to the urban areas. This is because in the Philippines, as is the case in other developing countries, liquid milk is an expensive item. Therefore, the milk can be converted into ready cash in urban areas where the majority of the population has a higher income group. This also

addresses the fact that milk is a highly perishable item requiring proximity of production and market.

Intensive upgrading is outlined for Regions III and IV to cater for the Greater Manila market, Regions VI and VII to serve the Cebu and Iloilo City markets, and Regions X and XI to serve Cagayan de Oro and Davao markets. These areas are considered milk sheds, where potential, specialised dairy production can later develop. Critical numbers of animals with a high percentage of riverine blood will be established in these areas.

Outside the milk sheds, upgrading will also be carried out but will be limited to the riverine blood in progeny to a maximum of 50%. Potential draft and meat animals are to be produced in these areas.

## **Enterprise development**

In target communities, we perceive the emergence of a specialised production system, a departure from the traditional notion that carabaos are raised mainly for draft. Today, this transformation is taking place in areas where the level of Murrah blood in their crossbreds has reached 75% or higher.

In these areas, our programme is to produce crossbreds that have a high potential for milk. There are sufficient data to indicate that productivity in crossbred animals increases with increasing levels of riverine blood. On this basis, continued selection and back crossing with high quality riverine buffaloes would create a mass of highly productive animals close to purebred after several generations.

The programme also takes into consideration the fact that carabaos are raised by farmers purposely for draft irrespective of agro-ecological zone. In these communities, the cross breeding will be organised so that the end product will be F<sub>1</sub> crossbreds with 50% riverine blood. An illustrative breeding programme is given in Appendix 2.

The enterprise development component of the programme also covers provision for training of farmers and assistance to community organisations and co-operative development. Part of the effort is the provision of access to required credit, mainly in the form of funds needed to procure breeding animals and support market development.

## **Research and development**

As a support to the programme, research and development is to be undertaken to address the perceived technical and policy limitations relating to successful programme implementation rather than channeling limited resources to laboratory-oriented research activities. Direction in various disciplines will be established by a Technical Working Group representing the different scientific and agricultural disciplines and various sectors of the industry, including farmers.

In general terms, the major emphases of research in the medium term are:

- Breeding—follow up performance of various crossbreds resulting from crossing Murrah and Philippine carabao.
- Nutrition—development of year-round feeding systems for small based production system.
- Health—reduction of calf mortality.

- Reproduction—improvement in pregnancy rate following artificial insemination; improvement in buffalo semen processing.
- Product development—refining processing and packaging of carabao milk-based cheese and sweets.
- Policy—development of suitable credit schemes for smallholder carabao production.

Details of the results of the 10-year research are published as FAO PHI/86/005 Field Document 13 entitled "Carabao Production in the Philippines".

## Major researchable issues

A review of the information so far generated have indicated that there are issues that remain in need of attention. Although most of the issues are interrelated, they are summarised below according to discipline.

### Breeding and genetics

One of the immediate objectives of the carabao projects was to determine the effect of crossing the riverine type buffalo ( $2n=50$  chromosomes) with the swamp buffalo ( $2n=48$  chromosomes). The resulting  $F_1$  has been characterised and was found to perform better than its swamp buffalo parents. These  $F_1$  crossbreds grow 75 to 100% faster than their swamp buffalo counterparts up to two years old and produce 250 to 300% more milk without detrimental effects on draft ability. A follow up study on the chromosome ( $2n$ ) number of the  $F_1$  crosses indicated a number of 49. Interestingly, the crossbreds of both sexes are found to be fertile with indications of slightly lower semen quality among the  $F_1$  bulls tested.

Follow-up studies involving *inter se* mating to produce  $F_2$  animals revealed that the chromosome complements of the offspring have chromosome number polymorphism, one group had 48, another 49 and the last group had 50 chromosomes ( $2n$ ) at a ratio of 1:2:1.

There is also a need to follow through the performance of the crossbreds resulting from *inter se* mating of  $F_1$ . Likewise, it would be valuable to define the production performance of  $F_1$  animals back crossed to swamp buffalo or riverine types as it relates to draft, growth, milk production, and fertility parameters.

In the light of the new understanding of the need to conserve genetic diversity as a means of ensuring that valuable genetic materials are available for future genetic improvements, there is a need to characterise the various available water buffalo stocks in the country. Since there are geographical barriers, it is important to understand the genetic distances between populations and their relationship with other swamp buffaloes in the region.

### Nutrition-related issues

One of the limitations in tropical animal production is climate, where pronounced wet and dry seasons exist. This limits the full potential of the animals from being expressed, particularly under the existing feeding regimens. In areas where the dry season extends up to six months, as is the case in northern Luzon, animals on pasture without supplemental feeding lose as much as 200 g a day, equivalent to

half the daily weight gained during the rainy season. The animals only attain their mature weight after relatively long periods.

The effect of seasonal feed availability also influences the reproduction efficiency of animals in the villages. This is translated not only in terms of longer post-partum anoestrus but also in semen quality of bulls. The pregnancy rate of animals reflects their nutritional status. Based on the above premise, future research should further focus on development of year-round feeding systems taking into consideration the available basal feed (crop residues and forages) and the amount and kind of supplement and when this should be supplied. An economic evaluation of the system also needs to be done.

Research efforts should also consider the changing nutritional requirements of the upgraded animals. The nutritional requirement for milk production and that of specialised meat production require some additional attention.

Nutrition-related research on the forage type and grass–legume mix appropriate for smallholder farming systems, further improvement of multinutrient blocks as a supplement to carabaos at different stages of production, and nutritional management of calves is required. One very important aspect that needs to be pursued is the field application of technologies developed.

## **Reproduction-related issues**

Many of the reproduction problems in carabaos in the villages are related to nutrition and general animal management. With the application of artificial insemination and use of superior bulls of the riverine breed, several issues have been raised. First, is the observed low pregnancy rate following oestrus synchronisation and artificial insemination (AI). Much has to be learned about the production and processing of quality buffalo semen. This has very large implications on the degree of success of AI and will encourage the use of the best bulls as semen donors.

At the field level, many of the failures in obtaining fairly good pregnancy rates are related to the proficiency of AI technicians, and more importantly, to the handling and use of frozen-thawed semen. This area may fall more properly under training than research, but has a large bearing on the overall AI performance.

One area that may need attention is the refinement of techniques on superovulation, embryo collection and embryo production *in vitro* as important tools in the propagation of superior buffaloes. Superovulation in buffalo has been met with formidable obstacles related with low embryo yield. Much of this is related to the failure of the treated females to respond to hormones even at levels reported to obtain very satisfactory responses in cattle. This limits the extent of ovulations and therefore limits the potential embryos from the donor animals. Efforts in the last five years resulted only in an increase of average transferable embryo harvest from 1.3 to 1.8 per treatment regime.

As an alternative to superovulation and embryo collection, *in vitro* maturation and fertilisation (IVM/IVF) techniques in buffaloes have to be refined. To date, the system developed can produce embryos but with poor quality. If fully developed, this technique will allow production of large quantities of high quality embryos in areas where riverine buffaloes, abound such as India. Transport of embryos is less expensive than transporting animals on the hoof and poses very limited risks in terms of animal diseases.

## Animal health

In the short term, improving calf survival can have a direct bearing on the overall productivity of carabao raising.

In the medium and long term, reduction in losses due to haemorrhagic septicaemia (HS) and *Surra* (Trypanosomiasis) is a major concern. The same is true for the need to eliminate foot-and-mouth disease (FMD), not only due to production-related reasons but also for trade purposes. These are major diseases that affect other livestock species and therefore a national focus is needed.

## Social aspects of development

Defining the best options for the farmers for co-operative development is crucial. Many attempts to develop farmers practices and welfare through this avenue have failed in the past. A thorough analysis of the previous approaches has to be carried out to identify the important lessons to be learned. The development of alternative options is essential for farmer co-operatives to succeed.

## Technology delivery

The major constraints to carabao development efforts are more on the delivery of the technologies to the farmers in technology development. There is a very low level of acceptability of some of the technologies. It seems important to establish if problems can be ascribed to delivery systems or the technology itself.

## Policy

The implementation of the General Agreement on Tariffs and Trade (GATT) is an international concern and we should be ready to address the needs of this important development in agriculture. Small-scale farmers are the most affected sector of the society and we ought to be on the alert. Improving production efficiency is a primary consideration, but there are major issues that concern the small farmers, particularly in the developing world. One is the issue of intellectual property rights (IPR). While genetic resources seem to be available in the Asian countries, poor Asian farmers—who are not in a position to manipulate these genetic materials but are in need of better yielding varieties and breeds—are both suppliers and consumers at the same time. Policy on this is a major concern as experience with crops clearly indicates that once the genetic material is isolated, its usage is dictated purely by financial considerations without regard to social responsibility. Some of the measures that would reduce risk to the smallholder farmers amidst the globalisation of markets should be identified and safety nets devised.

## Constraints to research

After identifying the areas where impact and relevance would form the basis for channeling research resources, the next logical question would be, can this be done? The factors that may limit implementation of the identified research are:

- **Technical manpower capability**—In some cases, there is an urgent need for upgrading and further training of technical staff. The pace of development of techniques, most particularly on the molecular level, is faster than we train people to use those techniques to advantage. Likewise, the requirement for

specialised laboratory equipment needed to carry out research affects overall technical capability.

- Sustained funding—While PCC has in its regular annual budget funds allocated for research, there are limitations imposed by the nature and magnitude of the requirements. For example, since the proposed genetic conservation is a sustained activity requiring special budgetary support, the funding source has to be defined. Of interest is the early recognition of the issue of conservation—but for whom? If the benefit of the effort will transcend political boundaries, then the cost of maintaining a regional genetic conservation programme has to be in place. This is an area where understanding, particularly of those in the policy making sector, is required.
- Information flow—A system for communication, exchange of scientific information and access to scientific journals are requisites for effective technology development. This is an area where investment has to be strengthened.
- Systems orientation—This issue has been emphasised in many fora. Both the problem and the solution have to be seen in the context of the system. This is not very clear to many policy makers. It affects the research focus and the needed strategies to address the perceived problem.
- Failure to translate the efforts to the farms—Often, scientists are preoccupied with the big tasks of preparing research proposals, defining the technicalities of a project and equipping the laboratories. The results are beautiful manuscripts published and presented in international fora. This is fine. But what has that to do with the farmers? Efforts in improving the productivity of the animals are not an end in themselves. These have to be translated in terms of benefits to farmers in the form of increase in income etc. We have to be very clear of this, and must establish whether we know our clientele.
- Programme continuity—There seems to be a failure to learn from the mistakes and lessons of the past. The tendency to develop new programmes has not always brought us very far.

## **Regional implications of carabao research and development in the Philippines**

In many respects, the South-East Asian countries share common agro-climatic conditions which to a large extent, influence the livestock landscape in each country. Indeed, the use of the water buffalo as a predominantly draft animal in crop-based agriculture in all Asia reflects this notion. Therefore, lessons learned from research and development in any of these countries will have significant implications for the future development efforts in buffaloes in other countries of the region.

The investment made by the Philippine government during the past 20 years and shared by UNDP and FAO during the last 10 years has resulted in a better understanding of the various ways in which the vast buffalo resource in the country may be fully harnessed. The resolve of the government to translate this into development for the millions of rural farming families is indicated by earlier efforts to establishment of the Philippine Carabao Center. This gesture of the Philippine government ensures that this important livestock commodity can be given the attention needed to become a potent tool to improve the well-being of a large sector

of the agricultural community in the country. But as we strive to develop approaches and technologies geared towards a more meaningful utilisation of the water buffalo, the lessons learned from these efforts should transcend political boundaries and have implications in the South-East Asian region.

There are areas, however, where sharing resources may be an option to solving problems in buffalo production. An example is the emerging concern on the genetic conservation which will potentially benefit the region more than each country. In this case, cost sharing is essential because the financial burden of maintaining a live animal pool is relatively heavy and sustained funding for this kind of project which does not have immediate impact, receives low priority among funding institutions and local decision makers.

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## Discussion following Dr Cruz's paper

- Siriwat: In Thailand we are studying the difference between using the Murrah buffalo and the native buffalo. We found that the chromosome number of the local one is 48 and that of the Murrah is 50. The chromosome number of the  $F_1$  is 49. When we use the males in the rice fields, they become stubborn when it gets hot and they don't work. Some of the females are infertile and we have problems when we give them to farmers. So we have slowed down the programme and concentrated on the spread of local buffalo. Do you have this problem in the Philippines too?
- Cruz: We have characterised the  $F_1$  crossbreds in terms of their ability to grow and ability to reproduce. We have produced a lot of females and we have gone to the extent of analysing their ability to conceive, their post-partum anoestrus and their ability to return to pregnancy, and we have not seen any significant difference between the non-cross and the crossbred animals. For the  $F_1$  male animal there are indications that the semen quality is less with 10% higher sperm abnormality than our native animals. However, the population of the  $F_1$  bulls that we have taken samples from is not as wide as we would like. The level of infertility, which may be 10% as estimated, is not expressed significantly out in the field.
- Diwyanto: Seen in the global market the price of milk is very low. Is it possible to sell buffalo milk in this region? Your slide showed that the performance of the crossbred is better than that of the local breed. Is that under the local conditions or improved conditions? Thirdly, since the animals belong to the poor farmer, is it possible to improve or to transfer technologies such as the embryo transfer technologies you mentioned to the village areas?
- Cruz: Our experience in the Philippines is that most  $F_1$  males are used as draft animals which under Philippines conditions, would raise about 3–5000 more than our native counterparts in terms of live animals for work.
- Can we utilise embryo transfer and *in vitro* fertilisation at the village level? No. In fact we are only developing this technique as a way to enhance reproduction of very superior genetic material for live animals. We are not intending this to be utilised in the field. This is a very specialised area and we would like to be clear that we are not choosing this on a large-scale basis.
- Mukherjee: We have been doing genetic distancing and chromosome work for some time with funding from ACIAR. I think the  $F_1$  animals will have 49 chromosomes and from the Malaysian examples (and I have seen reports from Thailand and the Philippines) the  $F_1$  animals are desirable animals. The farmers want them and there is no serious problem of infertility. The problem will come when you interbreed  $F_1$  animals. In the  $F_1$  you will get a range of chromosome polymorphism. You can get 48, 49 and 50 and in our programme we have actually sampled chromosomes from animals from 27 regions of five countries, including Sri Lanka, and we find that there is a problem of translocation, particularly the Robertsonian type of translocations,

some inversions and deletions. With the  $F_2$  and  $F_3$  generations there could be problems with regard to infertility. That is why my question would be, is it possible actually to have sire lines (from Murrah or RaviNili, Surti or whatever it is) and dam lines from any of the swamp buffaloes? Although there is significant genetic distance between swamp animals in the region, I think we could take it that this subset is not too different from each other, because the genetic distance is about 0.6. The advantage would be the production of hybrids and you can maintain male and female lines to avoid having too many  $F_2$  and  $F_3$  crosses. On the other hand, because the demand for dairy products could be higher in future, and because of the possibility of substitution of the draft animals by machinery (which has happened in Malaysia and may happen in future in the Philippines and Thailand), perhaps we should think about upgrading the animals. From  $F_1$  we can breed back to the sire lines and then we can upgrade them to the dairy animals if it desirable. What do you think?

Cruz: I think you are more in a position to comment on this, but we have outlined that during the short- and medium-term periods, the need is to be able to assess the performance of  $F_2$  and  $F_3$  crosses in terms of fertility. We have been concerned about that issue and there is a separate proposal to address it which I think is also part of the paper we will be distributing to you.

Leng: Geneticists tend to propose genetic solutions. I don't mean to be rude about that, but it always an interactive state. It was initially suggested that buffalo couldn't grow and reproduce. In fact it was a nutritional problem and buffalo can grow and reproduce at a fairly high rate if you feed them. In the world, there has been a greater pressure on resources, and protein nutrition generally has gone down. Nutrition by genetic interaction is an enormous effect. For instance, in the breed books the N'Dama of Africa is recorded as a 150-kilogram animal, yet there are plenty of 500-kilogram animal around now when they have been fed in their early life. Protein undernutrition at the very critical stage of weaning undoubtedly stunts an animal to the extent of 50–100 kg live weight. I don't say that there is no genetic component obviously but we have to be very careful when nutritional interactions are coming into play.

Cruz: Thank you for those comments, but I think our geneticists, including those from the FAO, were careful enough to include in the design of the breeding plan, crossbreeding and management at several levels, e.g. farm level and institutional level, to address what probably may be the genetic times environmental interactions.

Qureshi: There were comparisons between the swamp buffaloes raised under better nutrition and the point remains of nutrition at the time of selection.

Fitzhugh: It's more of a general issue that we are facing as an organisation. Traditionally, the CGIAR has focused on cattle and small ruminants, the small ruminants being sheep and goats. One of the questions that will come up within Asia are buffalo, and the relative emphasis to be given to buffalo. If, as ILRI, we propose to focus on large and small

ruminants, in this region what would you see being the relative proportion of research effort that should go into buffalo versus cattle?

Little: One thing of concern. We have been talking about conservation of biodiversity, various problems of what we select for and some of the so-called "less desirable" animals lost to the system. It seems to me there is room for discussion as to the sort of criteria, what precisely do we mean by conservation of biodiversity. We said we would be talking more about crossbreeding on the assumption that it is necessarily a good thing, and in many respects it is. But certainly the point that Ron Leng raised is absolutely valid about assessing how productive these animals can be and having comparable data. Discussion could be useful to help identify the sorts of characteristics of biodiversity that we wish to conserve.

Steane: FAO does have a quite clear definition of conservation. It may be a little different to the traditional use of the word which tends to become synonymous with preservation, and of course it is not synonymous with preservation. That is one of our major problems that people typify their reaction by a preservationist attitude. Can I say that our definition is essentially "the best present use and the long-term maintenance of the resource". It's quite clear that this is the exploitation for the present and a guarantee of the ability to exploit in the future. So it is nothing to do in the initial stages with preservation, although that may be part of the whole strategy which you adopt to maintain diversity. But conservation is a rather broader thing than that.

Qureshi: This is not just a FAO definition, IUCN for instance use this definition.

# Integrated crop–fish–livestock improvements in South-East Asia

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## Abstract

A systems approach is a prerequisite for the promotion of integrated agriculture/aquaculture (IAA) farming systems. This requires multidisciplinary and attention to the hierarchy of IAA systems from enterprise, through whole farm, to regional and national levels.

A sustainable development strategy for small-scale farms in South-East Asia may be through IAA systems because crop, fish, and livestock have mutually reinforcing on-farm linkages. These are essentially mixed farming systems, which occurred in Europe until the recent introduction of industrial agriculture. Their overall nutrient status requires raising to increase productivity and profitability; a balanced strategy of organic farming and off-farm inputs is recommended.

Research and experience have shown the difficulty of intensifying small-scale farmer monogastric/fish integrated systems in Thailand. National development favours vertically integrated large-scale production due to economies of scale in input supply and marketing. Small-scale farmers may have a comparative advantage only in the less developed countries.

Ruminant–fish integrated systems may have more potential for small-scale farmers because they do not need to be fed costly, formulated feeds. As farms diversify and intensify, increased amounts of green fodder can be cut and carried to animals raised in semi-feedlot systems. As ruminant manure stains pond water, thereby constraining fish production, research is required on cost effective means to separate and collect manure and urine. Manure may best be used as a crop fertiliser/soil conditioner but urine has been shown to be an effective fish pond fertiliser.

A more balanced approach to research is required to promote small-scale IAA. In addition to continued research to develop and improve technology, an acceleration of introduction of existing technology to various agro-ecological zones through situation appraisal, adaptive field research and extension research, is needed. These need to be combined with upgrading the educational and research capacity of developing countries in the region. Co-ordination of assistance from external agencies would facilitate the process.

## Introduction

The establishment of a framework is a useful exercise to guide thought and direct action towards a particular goal. A simple framework proposed by de Bono (1990) comprises the sequential steps of definition of purpose, clarification of concepts or philosophy to be followed, and selection of the means to achieve the purpose. The purpose of this contribution is delimited by the mission of the Consultative Group on International Agricultural Research (CGIAR): to assist in the improvement of the welfare of poor farmers and poor consumers (CGIAR, 1991). The title of the

contribution dictates a systems approach to agricultural development, in part because of integrated crop–fish–livestock farming (subsequently referred to as IAA, integrated agriculture/aquaculture). The CGIAR has a research-based mandate so research is central to the discussion.

An outline of research and education for the development of IAA in the tropics was prepared by the International Center for Living Aquatic Resources Management (ICLARM) and the Asian Institute of Technology (AIT) almost a decade ago (Edwards et al 1988). Since then environmental sustainability has received increasing attention following the World Conference on Environment and Development (WCED 1987). ICLARM recently made this a cornerstone of its strategic research perspective though promotion of research for integrated resources management (IRM) (Pullin 1994).

The traditional, agricultural science-led concept which has stressed production technology tended to neglect issues of inequity and environmental degradation. A new socio-ecological developmental paradigm centred on people's needs and on environmentally friendly development is required (Groves and Edwards 1993). Cai and Smit (1994) presented a systems framework to facilitate the assessment of biophysical (ecological), socio-political and techno-economic aspects, all of which require consideration for sustainable agriculture. They also distinguished systems hierarchy: enterprise, farm, regional, national and global levels. Frameworks have also been proposed for aquaculture (Edwards 1994). One of these frameworks (Figure 1) emphasises the means to promote sustainable farming systems (education, research and development) and the limited capacity (human resources) in developing countries in general.

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**Figure 1.** *A framework for the promotion of agriculture.*

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This paper outlines recent research findings on IAA are outlined here which indicate potentials and constraints. The increasing urbanisation predicted for South-East Asia also suggests the importance of intensified livestock production (Simpson 1993) and opportunities for low-cost fish production based on livestock waste to feed the urban poor. The role of IAA in peri-urban areas, and conversion of rice land to IAA to boost farm productivity and incomes, have important policy implications for the fast developing nations of the region.

Attention is also drawn to a perceived imbalance in the type of research and insufficient attention paid to the development of the human resources required for IAA systems to fulfill their potential in South-East Asia. The CGIAR has itself stated that its livestock research to date has not yet led to farm-level productivity increases (CGIAR 1991).

## **Traditional farms**

Agro-ecosystems in South-East Asia have yet to be comprehensively analysed but this is required if existing farming systems are to be improved by a better integration of resources (Ruddle 1991).

# Characteristics

## Crops

Small-scale farms are typically nutrient-poor and crop dominated in the warm-humid tropics, the predominant agro-ecological zone in South-East Asia. Wet rice is invariably present in lowland areas and is often the principal feature of the farm although there may be multiple cropping of other annual crops in the paddy fields. The availability of irrigation greatly affects the opportunities for crop diversification. There is usually permanent cultivation of annual and perennial crops, including staple roots and tubers, on dry land (upland). There may be a mixed garden of fruits, vegetables and root crops around the farmstead. The relative proportions of wet rice, upland crops, and mixed garden vary widely with topography, agro-ecology, and farm size/population density.

## Livestock

Livestock are generally few in number as they depend on feeds from on or near the farm. A few buffalo and cattle are kept mainly for draft, and there may be goats. Monogastrics, poultry such as chickens and ducks, and pigs, usually scavenge for much of their food. Livestock are increasingly penned or stalled in densely populated areas, seasonally or permanently, to prevent damage to crops.

## Fish

Contrary to popular belief, inland fish culture is not widespread in South-East Asia with probably much less than 10% of farms culturing fish. Asia does farm almost 90% of the world's aquatic produce but more than 50% comes from China (Csavas 1994). Aquaculture probably evolved in China due to the adverse effects of population pressure on wild fish stocks centuries ago but until recently there were adequate supplies of wild fish in Southeast Asia. An exception is in northern Vietnam where there is a traditional IAA in the densely populated Red River delta. Overseas Chinese were largely responsible for introducing integrated fish farming technology to South-East Asia but IAA appropriate to the diversity of farming systems remain to be developed and disseminated.

## On-farm linkages

For simplicity, only the major linkages are indicated in Figure 2 but there may be others. Besides fish, the pond may provide water for crops (rice nurseries and vegetables), livestock and for domestic household purposes. Pond mud may be removed as a crop fertiliser/soil conditioner. Livestock also feed on, or are fed, volunteer vegetation and invertebrates from on and around the farm.

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**Figure 2.** *Major (or only) interactions between the various subsystems in a crop-dominated small-scale farm.*

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Human manure is an integral part of traditional farms, intentionally or unintentionally. Night soil is re-used in Vietnam and used to be used by Overseas Chinese in South-East Asia; scavenging pigs consume faeces in less developed

areas such as Cambodia, Laos and mountainous areas of Vietnam when latrines are absent.

## **A systems approach to integrated farming systems**

The basic philosophy of a systems approach is that of holism: consideration of all variables that may affect the system. This requires multidisciplinary research. It is important to recognise the hierarchy of agricultural systems from individual plant and animal components or species, to farm subsystems or enterprises such as rice, pigs or the fish pond, to the whole farm, to macro-level systems such as input supply and marketing, and government policy. Inadequate research at any level may impede the development of the farm.

### **Whole-farm perspective**

A major characteristic of small-scale farms is their low nutrient status. Many have been degraded though unsustainable agricultural practice, particularly those on sloping land (Demaine 1994). Most are not currently sustainable socially either as they are not productive enough to support a decent standard of living.

Integrated farming systems that incorporate fish have usually been classified on the basis of the interacting components, e.g. rice/fish, pig/fish, poultry/fish or multicomponent farms with three or more linked enterprises (Little and Muir 1987). Research has concentrated on commodity production with limited consideration of the broader farm or regional environment.

ICLARM has made the case that IAA are best regarded as a form of integrated resources management (IRM). Here the emphasis is on farm resources in toto—land, water, nutrients, biota, capital, labour—and includes resources derived on- or off-farm. The IRM approach can also be applied to watersheds and to ecosystems/agro-ecosystems. IRM is a useful concept because it encompasses the farmer's perspective: optimal utilisation of resources under his control whether his aim is primarily subsistence or sale. There are a number of different methods of farming systems research which have in common an holistic approach to account for the heterogeneity and complexity of small-scale farms (Altieri and Anderson 1986; Simmonds 1986).

IAA systems may well be the most appropriate where topographical and climatic conditions permit fish culture (Edwards et al 1988). Farming systems in Europe and North America evolved from crop dominated systems through mixed farming systems (integrated crops and livestock, although without fish), before the advent of industrial monoculture of crops and livestock (and fish). A major premise of the ICLARM/AIT IAA study is that major sustainable increases in developing country agriculture can be made by promotion of mixed crop and animal (livestock plus fish) farming systems (Edwards et al 1988; Lightfoot and Pullin 1991).

Crop diversification may be required to upgrade the farm, including agroforestry. Trees counteract soil erosion and increase the organic content, fertility and water holding capacity of the soil. Nitrogen (N)-fixing legumes play a particularly important role (Charlton 1987). Increasing crop diversity and cropping intensity would help to resolve a major negative feature of small-scale farms: limited feed supplies (Devendra 1983).

Livestock should be assured a place on a small-scale farm, even with mechanised ploughing, because 60% of the annual production of digestible feed is not useful as

human food (Javier 1978). Livestock collect and concentrate dispersed nutrients as well as process crop residues (Spedding 1979).

It has been pointed out that the fish pond in an IAA system serves as more than a sump for wastes, and to produce fish (Little and Muir 1987; Pullin 1994; Pullin and Prein 1994). It may provide water for household use, for livestock, and nutrient-rich water and mud for crops. Pullin (1994) stated that fishponds were pivotal to the working of the whole system. A major role of the pond is as a small-scale reservoir, especially in a rainfed area. This is a major research need in which irrigation engineers working closely with IAA specialists should seek to optimise designs for different soil, groundwater and topographical situations. Pond systems in Buriram in north-east Thailand have recently been expanded at the expense of rice fields, mainly to irrigate high value fruit trees and vegetables, as well as to produce fish. Although inorganic fertilisers are used, crop productivity is constrained by the low organic matter content of the soil which could be increased by livestock manuring. The Buriram experience is a good example of the potential synergism of IAA systems. Conversion of rice fields to multi-purpose ponds is also starting to take place in the Red River Delta in northern Vietnam and has raised the spectre of reduced national rice harvests as farmers seek to diversify. Any successful promotion of IAA may begin to have important local, regional and national impacts on the type and quantity of food produced.

Increased levels of inputs are essential (FAO 1984) but a balance is required between the slower but environmentally sustainable methods of organic farming and more rapid increases through industrial agriculture (Ikerd 1990). An attempt was made to upgrade pond aquaculture in north-east Thailand through an agro-ecological approach, but because of limited on-farm resources successful technical interventions depended on a combination of on- and off-farm inputs: a mixture of rice bran and duck feed concentrate to produce large fingerlings which were subsequently released in a pond fertilised with buffalo manure (BM) and urea (Edwards et al 1991). Research is required on nutrient dynamics to permit strategies for effective nutrient management to be designed (Devendra 1992; Edwards 1993). Major questions for research concern whether to fertilise the crops or the fish pond; whether crops and crop residues should be consumed by humans, livestock or fish; and whether livestock manure should fertilise the crops or the pond (Edwards 1993). Bioeconomic modelling of whole farm systems should improve our ability to predict and advise farmers for given situations.

Fish and livestock may have other important roles in farmers' IAA systems. The impact of animals in the integrated pest management of flooded rice fields is largely unresearched but has great potential. It has been assumed that fish stocked in rice fields were important control agents of rice pests but it is only recently that research has focused on this issue (Halwart 1993; Kamp and Gregory 1993). Anecdotal evidence suggests that ducks and chickens may also have valuable roles in the control of insect pests.

Research needs of IAA, whilst clearly demanding a whole-farm approach cannot be limited by one. The overall livelihood of rural households needs to be considered (Ruddle 1991; Lightfoot et al 1993), particularly in rapidly developing parts of South-East Asia, and set within a macroperspective of regional and national development.

## Macro-perspective

Off-farm factors such as input supply and marketing assume increasing importance as the farming sector of a region or country enters the market economy. Although pigs and poultry comprise almost 50% of the cash and nutritive value of livestock in developing countries, the Technical Advisory Committee (TAC) of the CGIAR "has not considered their research needs to be of sufficient high priority to justify their inclusion in CGIAR activities" (CGIAR 1991). Economic development in Thailand has depressed traditional livestock production, particularly poultry and pigs that require grain/grain by-products. In contrast, in many parts of Indo-China intensive feedlot poultry and pig production is undeveloped. This is due in part to the still widespread practice of milling paddy at the household level and to the unavailability of teed concentrates. Traditional livestock breeds and production systems often still prevail in rural, less developed regions or countries although there may be a tendency for them to be undermined by competition for feeds and markets and by mechanisation of ploughing. Government policy on input prices and availability, particularly additives and concentrates can affect the competitiveness of small-scale relative to larger producers.

Commercial, vertical integration of feedlot livestock using improved breeds and formulated feeds, whilst leading to opportunities for large-scale feedlot fish culture, may compete for the feeds and markets of backyard pig and poultry producers, reducing their economic viability (Little 1994). Small-scale farmers may have a continued relative advantage in the production of ruminants and village poultry because of their forage-teeding base and special characteristics (taste, texture and 'organic' origin), respectively. In general, however, these systems must be upgraded to meet the farmers' expectations in terms of overall net benefit and some degree of intensification is probably necessary for any integration with fish culture to be sustainable. Market development and veterinary support, however, are often critical to the development of such improved systems.

The waste concentrations produced by vertical integration of pig and poultry production may be most effectively re-used by aquaculture. Widespread adoption of this practice in Thailand provides low cost herbivorous fish for poor urban consumers. Moreover, there is further scope for more intensified and yet environmentally benign use of these 'agro-industrial' wastes (Little and Edwards 1994).

## Upgrading traditional livestock systems for aquaculture

In practice, livestock manures from unimproved systems may not be useful for aquaculture. The measures may be too little to use because of the difficulty of collection from small numbers of free-ranging animals, too poor in quality because of limited and/or low quality feed, or unavailable because of competition with crops .

The greatest potential for upgraded livestock production probably lies in the improvement of semifeedlot systems, i.e. an intermediate form of management that combines grazing/scavenging and teedlot (Little and Edwards 1994). These systems combine the low-risk advantages of traditional systems while enhancing productivity. Such systems should also produce more and better quality livestock waste (manure and spilled feed) that can be collected for use in fish culture and enhance the overall nutrient use on the farm. The nutrient-poor status of

small-scale farms contrasts with the high losses of nutrients, particularly N, that occurs before collection and re-use. The N from backyard poultry waste and urine from ruminants are often almost completely lost.

The major constraints to using ruminant manures are collection, transport, and their low value and bulk. Fish culture may be integrated with traditional livestock management practices through linkage with the needs for watering, wallowing or overnight corralling. Manures may be deposited in ponds without physical destruction by designing them to allow walk-in entry of large ruminants.

Large ruminant manure (buffalo and cattle) is a common fish pond input in South-East Asia although its efficacy as a pond fertiliser has only recently been assessed (Edwards et al 1994a; 1994b; Shevgoor et al 1994). The AIT research demonstrated that buffalo manure (BM) is a poor pond fertiliser with a dry matter conversion of BM to fish of %. Farmers, in a researcher managed trial, loaded 4 t of fresh BM into a small pond over a 6 month period but harvested only 20 kg of fish. BM had a low nutrient content and tannins stained the water brown, inhibiting light penetration which limited phytoplankton production, a source of fish feed. It was recommended that BM should only be used at low loading rates in fish culture and be combined with other inputs.

Subsequent research, both on-station at AIT and with researcher-managed on-farm trials in north-east Thailand, investigated supplementation of low amounts of BM with urea as a pond fertilisation strategy. This increased fish yields by 300% over unimproved systems (Edwards et al 1991) and has been shown to be economically viable (Setboonsarng and Edwards 1994).

Inadequate feeds and their poor utilisation are key constraints to improved ruminant systems (Devendra 1983). The greater use of crop by-products, undergrowth of tree crops and improved fodders, particularly legumes have been promoted to, and adopted by farmers (Devendra 1990). The use of supplementary concentrates such as rice bran can further improve performance, especially of pregnant and lactating animals.

The biggest challenge is to improve the feeding value of the large amounts of lignocellulose material available (Devendra and Chantalakhana 1992). The use of pretreatments using alkali or urea, which improves fibrous feed quality, has been promoted but not widely adopted by farmers (Jones 1988).

Improved feeding often develops together with more confinement of ruminants in small-scale farms in Asia as farms decrease in size due to human population growth. Animals that are stalled, some or all of the time, and fed cut-and-carried forages and/or concentrates, tend to show increased productivity and produce wastes of higher quality; the wastes are easy to collect. The animal and waste production from different levels of intensity of meat goat management support this (AIT, unpublished data). The use of daytime tethered grazing, supplemented with a concentrate (rice bran) or cut legume leaves increased productivity and waste production relative to tethered grazing alone. The supplementary use of leguminous leaves in particular improved the collectable N in wastes almost to the level of zero-grazed animals. Pagbilao (1992) found that solid and liquid wastes were greatly improved with increased levels of leguminous leaves in a cut-and-carry system.

The frequency of waste removal from goats kept in stalls overnight affected both the amount of collectable nutrients and animal productivity. The animals that slept on infrequently replaced bedding showed reduced productivity and the amount of

nutrients collected, particularly N, was substantially less than amounts from stalls that were cleaned daily (Little and Edwards 1994).

Research has also been conducted in the Philippines (Libunao 1990) and at AIT on the effectiveness of goat manure as a fertiliser for aquaculture. As with buffalo manure, faecal matter from goats stained the pond water. However, liquid wastes (urine plus washing water) contained about half of the N produced and this could be used to totally replace inorganic N in fish production (Mohsinuzzaman 1992; Little et al 1994). Phosphorous levels in the waste were greatly enhanced by using rice bran as a supplementary feed.

As the amount of faecal waste that can be used in fish culture is limited by both their low nutrient density and high concentration of tannins that negatively affect water quality, an optimal strategy under many conditions may be the use of solid wastes for crop fertilisers and the collection of urine and washing water for fish culture. The collection and retention of the urine N in the farming system is problematic. Generally the urine simply soaks away or is absorbed by bedding and solid faecal waste. Using greater quantities of bedding materials high in carbon improves N conservation (Kirchmann 1985) but these are often unavailable in the quantities required. Pens with sloping concrete floors in which urine and washing water could be easily directed into a plastic bags can be used but concrete may be unavailable. Elevated, wooden pens are often favoured for goat husbandry and may be ideal for directly stalling the animals over the pond. In practice, however, livestock may be penned away from the pond so that waste has to be collected and carried. Practical methods for urine collection are required, perhaps through the use of simple plastic sheeting and bags.

## **Monogastrics**

The number of monogastrics that can be raised is linked to the availability of grain and bran, and/or surplus root crops. Backyard poultry flocks depend on scavenging for most of their feed with some supplementary feed. As the number of livestock is limited, so is the amount of manure that can be used to fertilise crops or the fish pond.

Research at AIT aimed to intensify poultry and fish production in north-east Thailand. Both farm enterprises are traditionally extensive and marginal parts of the household's livelihood. Poultry typically scavenge in flocks of less than 30 animals during the day and receive a feed supplement in the evening, usually rice bran, when they are penned for the night. Since the poultry tend to scavenge for natural feeds high in protein, only a low-protein, high-energy supplementary feed needs to be given during confinement at night (Little et al 1992). Formerly the paddy was hand-milled which allowed considerable numbers of poultry (and previously pigs) to be raised by the average household. This is currently the practice in most of Indo-China. In north-east Thailand, however, the paddy is milled in a village rice mill and the bran is retained by the miller as a milling fee. Thus, farmers need to purchase bran which limits small-scale livestock production (Little et al 1992).

The only field crop grown in north-east Thailand which could be used to intensify poultry production to the extent that sufficient manure would be produced as a fish pond fertiliser was cassava. Cassava products (root meal and leaf meal) were used to replace rice bran but duck growth performance remained satisfactory only up to 50% inclusion level in a rice bran-based supplementary feed. The N content of the

cassava-fed duck wastes was higher but the amount of faeces was lower than in rice bran-only diets and fish yields were lower with the cassava products.

Farmer-managed trials are currently underway in north-east Thailand (Little 1994) in which recommendations concerning supplementary feeding of poultry and use of the waste in fish culture are being tested. Use of on-farm cassava products up to a level of 25% of an egg duck diet, and 50% of a muscovy grower diet, are being recommended based on on-station research. Adoption of these feeding levels should permit expansion of current flock size by 25 and 50%, respectively, for the same amount of rice bran currently used by farmers. The use of old fertiliser bags to collect and transport duck wastes to fish ponds every 2–3 days is being recommended. The results to date have been disappointing due to farmer reluctance to collect cassava to include in supplementary feed. This may be related to the relatively high opportunity labour cost in Thailand. Better results might be expected in other parts of the region where there are fewer off-farm employment opportunities.

Other research demonstrated the relationship between supplementary feeding of poultry and both quantity and quality of wastes available for fish culture. Wastes of Pekin and muscovy meat ducks fed crushed sorghum produced poor water quality for fish, largely due to the high tannin content of the feed (Naing 1990).

Traditional pig production, which still occurs in Indo-China, utilises cultivated and volunteer green fodders, as these can be consumed by local breeds, but also considerable amounts of grain by-products or root crops such as sweet potato or cassava. This means that the number of animals raised by each household remains low. Pig research has concerned improved breeds with increased reliance on formulated diets. There has been little to no research done to upgrade traditional methods of pig raising or their potential for integration with fish production.

## **Public health considerations**

The consequences for public health of IAA systems, particularly with regard to their role in the evolution of new influenza viruses have been debated at length (Pullin 1994). Considerable interest has also been shown in the risks associated with re-using manure in fish ponds, but hard data have been presented with the exception of the use of human waste which was reviewed by Edwards (1985,1992). The relationship between fish pond construction and the spread of malaria and schistosomiasis has been proposed but challenged (Pullin 1994). Probably one of the most important, but least publicised, health risks in the promotion of aquaculture in South-East Asia are the food-borne trematode infections, particularly among populations eating uncooked fish (Pullin 1994). Agrochemical use within IAA is of concern. Insecticides, antihelminths and cleaning/disinfection agents used in livestock production may affect fish production and consumers. Prophylactic medicants and feed additives have been related to bacterial drug resistance but their effects on waste re-use in fish culture are unknown. Overall, the health risks associated with current and increased use of manure in IAA should be based on risk assessment. The use of the Hazard Analysis and Critical Control Point (HACCP) has been advocated and its increasingly adopted to prevent human infections from aquatic produce (Pullin 1994).

## Technological mismatch

Two component livestock/fish systems (pig/fish or poultry/fish) are often considered to be synonymous with IAA and are promoted uncritically by development agencies for small-scale farms (Figure 3). Impressive fish production is attained in such systems but they have been described as a mismatch of technology to resource base (Edwards 1994). Feedlot livestock is an example of industrial agriculture with, usually, genetically improved livestock fed high levels of relatively costly formulated feeds. Promotion of such systems rarely succeeds on small-scale farms once technical or financial project support is withdrawn.

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**Figure 3.** *Major (often the only) interactions between the various subsystems in a feedlot–fish integrated farm.*

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Both ICLARM and AIT conducted on-station experimentation with feedlot livestock/fish more than a decade ago in the Philippines and Thailand, respectively (Hopkins and Cruz 1982; Edwards 1983). AIT also carried out on-farm trials with a feedlot duck/fish system. Fish yields were high enough to provide almost the entire animal protein needs of a typical farming family from a pond area of only 200 m<sup>2</sup> above which were penned 30 ducks. Co-operating farmers were unable to sustain the system because of high feed costs and problems of securing both the inputs and marketing the produce in rural areas.

Small-scale, however, is a relative term for both fish and livestock production. Engle and Skladany (1992) described a profitable egg layer chicken-fish system in one area of north-east Thailand. Although farm size was within the norm for the region, these operations tended to be in irrigated areas and highly capitalised compared with typical, rainfed farms in the area. The concentration of operations close to a provincial urban centre also favoured the provision of cost effective inputs and sale of produce and the scale of operations favoured the farmer–middleman relationship.

## Research imbalance

Most scientists tend to focus narrowly on component research, either in the laboratory or on-station, to develop or improve production technology as though the major constraint facing the promotion of agriculture were a shortage of technical knowledge. Far more important constraints in developing countries are the limited ability to assimilate existing technology and the limited local capacity of both individuals and institutions (Juma and Sagoff 1992).

In addition to continued research into the development and improvement of technology, more farming systems research is required on the introduction of existing technology to specific agro-ecological zones. The TAC recommendation that a "farming systems perspective should be adopted for formulating and implementing research programmes" (CGIAR 1991) is endorsed, and this is particularly so for IAA. There is need for increased:

- situation appraisal to assess the needs for, and the benefits from the introduction of existing technology to specific agro-ecological zones.

- adaptive research to assess and modify existing technology for farms in specific agro-ecological zones
- research into extension to identify means to widely disseminate the adapted technology within various agro-ecological zones.

Relatively little progress has been made towards institutionalising farming systems research and extension concepts and procedure within national programmes (Craig 1988). Special emphasis should be placed to that end. Mechanisms need to be established to upgrade local educational and research capacity. These would be most effective if they were combined with agricultural development within the various agro-ecological zones under the responsibility of each developing country institution. Effectiveness would be further enhanced by co-ordination of effort of international and regional agencies and developed country national institutions (AIT 1994).

## Summary

A number of research needs are clearly required for the wider adoption of IAA in South-East Asia both at the macro and farm level (Table 1).

**Table 1.** *Research needs.*

### Macro-level

- Input supply—promotion of inorganic fertilisers, and feeds (concentrates, additives and formulated feeds)
- Feeds import policy (taxation etc)
- Market, consumer preference and market elasticity for traditional and new livestock breeds
- Overall national policies on industrialisation and export promotion and their effect on the cost of resources and their relative competitiveness for IAA
- Conversion of rice fields to ponds and IAAs

### Farm level

- Description of the great diversity of actual and potential IAA systems in South-East Asia
- The role of fish, ducks and chickens in integrated pest management
- Integrated nutrient management in IAAs, including seasonality effects
- The role of ruminants in legume-enriched farm environments within IAAs
- The impact of agrochemicals within IAAs
- Microtopography and soil effects on optimal IAA design
- Bioeconomic modelling

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# Discussion following Dr David Little's paper

Mukherjee: I think you have represented the issues that are related to integrated livestock–fish crop production systems very well. In Asia we have about 8% swamp lands and we see that subsistence animal agriculture along with the aquaculture is practicable in those swamp lands, especially in the coastal aquaculture areas. There are non-fin fish species, e.g. oysters, clams and mussels that are high-value fish, so if we really want to attract people to this kind of subsistence system we have to also look for high value fish not just catfish or tilapia or even carp. Asia is changing. We should look into the possibility of integrated production systems which could be industrialised, which could attract capital investment from the people who can invest. The integrated production systems will lead to problems of pollution, but that can be rectified. We have also seen that the environmental laws in Asian countries especially are becoming very strict. We have worked quite a lot on the density of the livestock, e.g. what should be the actual number of ducks that could be carried over the pond or beside the pond. Should we look at the different kinds of cycles in the integrated fish ponds (nitrogen and carbon cycles) to evade the pollution problems? Some work in this regard has been done in Europe, but very little work has been done in Asia. The other considerations, as you have mentioned, is the problem of human health which has to be looked into.

David Little: I think we recognise Asia as developing extremely fast, but there is a dichotomy and that is why I tried to break the talk into the two areas, by giving some descriptions of the work we are doing on the low input side with small-scale farmers and then finished with the intensive side of integrated farming which is clearly entrepreneurial. But I think both have to be looked at.

Leng: Amongst the alternatives you've given us I want to suggest another that is the integration that a biogas digester can give the whole system, its potential production of fuel for the household (which often is actually more important than food production) and the minerals are available for any sort of plant growth in water.

David Little: I think a general point about integrated agriculture–aquaculture systems is "the simpler the better". One input into a pond is a lot easier to adopt by a farmer than another step, and there have been numerous attempts to introduce biogas at the household level which have tailed, maybe because they were not relevant at the time and place or the technology itself was uncertain or unusable. Certainly where electricity is available, it is not as attractive as it might seem, in my experience.

Thomas: David, the system you described for using manure from pigs to produce blow fly larvae. Is this a seasonal activity and if so, what does the farmer do for the rest of the time when the blow fly are not producing eggs?

David Little: In the area where this farm is located, air temperatures drop in the north-east part of Thailand, perhaps lowest down to 15°C. The developmental times of the maggots they are using increases by a day

or two, but it is all year round technology under these conditions for the species of fly they have and the method they use. If you use this system we worked out that its real value is in a peri-urban area where you've got concentrations of pig production and lots of waste, but you can utilise a much smaller area.

Fitzhugh: Your descriptions are very interesting. How far are you at this point in putting numbers on the nutrient and the economic flows to get at the systems analysis? Are you finding that easy to do or what sort of data is needed and what sort of research needs to be done?

David Little: We have quantified a good deal of them and we are now starting to use this as a basis for bioeconomic modelling. Some are better than others; the duck/fish work was completed a long time ago and we have full input-output economic and nutrient data for that, less on the buffalo system.

Devendra: This subject, which you have so nicely presented, is certainly very interesting and potentially sustainable, but, to say the least, acutely complex, and coming from the research perspective there are two very major constraints. Firstly, is the element of training. It involves very strong multidisciplinary and understanding of how to look at one subsystem affecting the other, measuring the interactions etc. I am not sure that training is available and therefore I would suggest that this is a very major constraint if we haven't attacked the problem at all. And related to this is the development of methodology that can attack these very complex things. I wonder how you see it?

David Little: They are complex and not complex. I think the things that work best are the simplest. The last two examples of the maggot/catfish and the use of chicken offal have not been the result of research. That is the farmer entrepreneur developing those systems for his own profit. Regarding the vac systems of nonh Vietnam, much of what has been written has been very descriptive and even the descriptions, for instance, lack one of the main inputs in the system which is human waste. So we need better qualitative, descriptive understanding of the systems, but it does need to be backed up, you're right, by a multidisciplinary approach.

Devendra: What are the training needs?

David Little: Training in terms of teaching people how to think and analyse rather than given them recipes or menus. That is what we try to do at AIT, both in the MSc programme and short course programmes we run.

Siriwat: Mixed farming like this in the old times was really rare, but after we introduced some mixed farming in the lower land, ponds were dug. But in the upper land, people have less chance, but because of government promotion we are now concentrating on beef raising. If a farmer raises five cattle he can receive a loan from the bank and get support. With a loan, last year farmers were asked to pay for the veal at US\$ 250, so that the farmer got a half-acre pond. But, this year, if farmers join the project they get the pond free, to promote farmers in the highlands to keep the water.

Fitzhugh: You mentioned co-operation with ICLARM, several times. It would be helpful if you would relate AIT's contribution as we will hear ICLARM's contribution later. Where do you see the interface and, as you look to the future, do you see working more closely together or may be splitting out different activities where you would take lead and they would take lead?

David Little: We've had a number of interactions; this one is nearly 10 years old. I think it laid quite a good baseline or outline for research and education needs towards integrated agriculture and aquaculture which was a joint production. We've had postdocs based at AIT looking at some of these aspects—such as the introduction of plankton so that filter feeding fish can grow and produce—and there has been a large body of work directed just at that; we work quite closely with ICLARM, starting maybe 10 years ago. I think integrated nutrient management is very important using the pond as a focus. These are things of great mutual interest between us and ICLARM although the phytoplankton base production is very important, detrital food pathways in ponds are also very important. The fish pond has been called "a sunlight rumen" but there is very little work done on the microbiological aspects and maybe this is where ruminant scientists also have a role. This is something we have identified with ICLARM as a piece of joint research and we are developing proposals at the moment looking at detrital food pathways. We have just started with ODA funding, some testing of improved tilapia germplasm. ICLARM went back to the wild strains of tilapia in Africa to build up a basic breeding programme and we are now part of that regional programme and we are quantifying and checking the performance of these fish in a variety of fish production systems in different agro-environments.

Fitzhugh: Is either ICLARM or AIT focusing on the economics of agriculture?

David Little: Yes, specifically as bioeconomic modelling. It's more than integrated nutrient management. It concerns how much money, what difference it makes in the farmers' pocket, what are the trends? Should rice bran costing 3 baht a kg be fed to the fish or fed to the livestock? You can do that sort of bioeconomic modelling on the back of an envelope once you have the basic data. But, you can do a lot more if you use some of these dynamic models ICLARM developed using Ecopath and which we are developing at AIT.

Leng: Crustacea?

David Little: Our focus, in terms of research, is fresh water although our teaching programmes covers the whole spectrum of aquaculture and how aquatic resource management, so we consider wild fisheries and other aspects of production. In Asia, the story is dominated by the black tiger shrimp which is now Thailand's biggest export, and that's come from nothing in less than a decade. Our focus is on environmentally compatible systems, looking at how we can ameliorate the effect of intensive crustacea production. There is, however, through Asia a lot of interest in macrobrachium or the giant fresh water prawn. In the Mekong Delta of Vietnam, Bangladesh, and west Bengal there is increasing interest in these species. They have higher value but are more difficult to grow. We have looked at them, through student thesis

research and some project research but its not our main focus. Our main focus is a poveny focus, producing and concentrating on tilapia, carps and catfish which together are by far the most important groups as Asian food fish.

Hayakawa: Dr Little, thank you for your presentation. It was an instructive education for me. On this occasion I would like to introduce our new project—the farming systems in the Mekong Delta in collaboration with Cantho University and the Quiron Delta Research Centre. We are very interested in the rice growth, and livestock and fish culture that you mentioned. That programme will run for five years, and we will evaluate the on-going scale of the farming in Vietnam and the social influences on this farming system. We hope to dispatch our specialists concerning rice crops, livestock and fisheries. So in the near future we want to hold a seminar on this theme. I think this kind of farming system is very imponant for the Asian livestock industry. We want to strengthen this kind of field: JIRCAS wants to do collaborative research work not only in Vietnam, but also for the other neighbouring countries with results that may be applicable to other countries in the region.

## General discussion on day 1

Qureshi: What is happening to the indigenous carabao population at the same time [as your improvement programme], and also what is the percentage of the population involved in cross breeding?

Cruz: I prefer when geneticists answer that kind of question; in development programmes irrespective of the species, there are both technical and political.

In the area of buffalo improvement in the Philippines, when we talk about improving or cross breeding the buffaloes, we are not talking of envisioning a total population of crossbreeds. As we indicated earlier there are specific milk-production systems we would like to tie up with potential markets in the future and this is where the intensive upgrading will have to be carried out. In terms of percentage we are targeting only about 25% of the total buffalo population.

The main considerations in this kind of programme would be to develop numbers of animals that in the short or medium term will benefit the people that need improvement. As opposed to cattle I think buffalo are more closely related to the poor farmers and in terms of assistance, whether it is development or research, the buffalo with these small-scale farmers may need some government assistance. The private sector probably will be in a better position to support research and development of beef cattle.

Steane: To start any cross breeding programme that is going to be sustainable (and I believe in cross breeding very much) one needs pure breeds and a plan as part of your strategy. So I don't see any particular conflict in using cross breeding for most of your commercial production as long as you plan it properly. I think that's a question that has been avoided in many countries, that they have just gone down one road and haven't thought it requires at least two breeds to have a good continuous cross breeding programme.

Secondly in theory, in the pure breeds, yes selection reduces variability. In practice, in all animal breeding, I think we have to remember two things. Firstly, animal breeding is an extremely slow way of making improvement. We are talking about 1 or 2% per year maximum. Genetics is a long time business and I only justified on that basis.

In theory we should reduce variance, in practice we find we don't very much. After 20 or 30 generations in some cases, we can see a reduction in variance, not in others. Twenty generations of buffalo may take about 150 years. In fish you have a generation interval which is so short we are talking on a different time scale.

Certainly in the plans that we are making we can take precautions as well. We are suggesting every five generations laying down a batch of semen. If you only made a maximum 10% change, the correlated changes in traits you're not measuring is not going to be vast in five generations. Strategies have to take this into account, but I don't see it as a major problem if people do think through the strategy.

**Fitzhugh:** The questions you raise are the questions that are being brought up fairly often and it's probably the reason why there is some interest behind conservation of domesticated animal diversity because there is always that worry that maybe through either selection or through crossbreeding we are going to lose something.

But theory would suggest that within inter-breeding populations such as the breeds we are dealing with, that selection and cross breeding is not going to cause loss of genes. They might make combinations of genes more difficult to find, therefore you might not be able to access them nearly as well as you can knowing that they are within a population carrying a readily identified marker, like the red coat of white/red Holstein cattle. Whenever you cross breed them with blacks you lose identification of the gene but it is still there. I believe after a number of years the reason why animal breeders are now standing behind the need for these conservation programmes is more in terms of characterisation and primarily the characterisation of indigenous populations that have been separated for a fairly long period of time, as was pointed out for a number of populations that are here in Asia. The belief is that these populations have been under natural selection for such a long period of time, they have developed quite different sets of gene frequencies and by knowing that those frequencies are there or those alleles are there (for example resistance to internal of parasites being one case in point) then we are more likely to be able to go to those populations and find them.

**Qureshi:** You may like to characterise the species that ILRI is going to concentrate on.

**Fitzhugh:** These will be large ruminants and small ruminants because of decisions made by the donors who support us and at this point that's where we will stay. And we will primarily work through national research institutes to actually do the characterisation and we feel very strongly that this characterisation, at least at the phenotypic level, must be done under village or farm conditions. The characterisations on stations can mislead you because you change the environment and their phenotype is no longer a clear indicator of adaptive traits. But we see our role being primarily to assist and work with national scientists to do this work, to bring more resources into the area and work with FAO on the conservation aspects. We see the focus of the research that we will be doing primarily at the molecular level, developing methodologies that will be used to better characterise populations. Methodologies may work across many other species, as well as for the four major species of large and small ruminants.

**Leng:** The problem that I have with a lot of this preservation work is one of priorities. Far from being antagonised by the preservation of species I am for that but I don't know how we can spend the amount of money that we were spending on it when we have got such an important job to do with other areas of production and nutrition.

**Qureshi:** Talking about priorities in FAO, this year and last year we had discussions and we came to the conclusion that it is a question of objectives. What are we shooting at? With animal genetic resources conservation our objective is preserving diversity, production is not

the objective. The objective is biodiversity with production system improvement. Nutrition and other inputs, health, breeding improvements etc, these are the production improvements. Then our target is the farmer for food production as well as the low farmer income. And then we also have transboundary animal diseases that Dr Sasaki showed in the subprogrammes and there our objectives are the pathogen at whatever cost and that's different economics. When you are talking about production systems, how breed improvement goes into increasing production there you look at the relative importance of cross breeding, feeding and question of relativities. I am not justifying anything. I am only putting it in this perspective of objectives and then assigning priorities.

Leng: How is biodiversity going to improve the lot of the poorest of the poor? There are millions of people on this earth who don't have diversity even in food, they eat cereals every day.

Steane: I think we should try and get it into perspective in another sense. Firstly, we know that half the genetic variation is between breeds and a half within breeds—it depends very much on the characters you are looking at and the strategies we can adopt. I certainly am not for preservation of all breeds. I believe our responsibility is to maintain diversity to allow us the maneuverability that we need to provide for the demands of humans. We can get rid of breeds as long as we know whether they significantly contribute to the diversity of that species or not. But at the moment we do not know that at all—either in animals or in plants. I hope that we do not build up magnificent stores full of genetic material without actually knowing what it is all about. I hope that we will do the genetic analysis and this is a plan where ILRI will fit in very strongly, so that we can devise strategies to maintain diversity but not necessarily to keep breeds.

Fitzhugh: We are here looking at priorities for livestock improvement. We claim that this research we are providing today will serve the future. It may not help the poorest of the poor today or even tomorrow but presumably at some time in the future. It is recognised today that it is poverty that is a great threat to biodiversity. The issue here is not so much conservation, or even allocating very many resources to it, but it is actually to determine what value if any goes into conservation or justifies it as a researchable area. I don't think we are arguing to take away some money from nutrition or from reproductive physiology or whatever, but we do know that society has decided to invest in conservation of biodiversity and from a research standpoint we need to determine what level of investment needs to go into the livestock side.

Mukherjee: I think molecular characterisation work is not done to conserve everything. The main idea is to see how the populations are genetically distant and genetically related. So the idea is not to conserve everything but to conserve a few things which are the representatives of certain sets. So if we have, say a thousand varieties in one country, there might be 9 or 10 which will be saved and conserved.

I think we should also look at the genome maps. If genome manipulation actually is to become a reality in future, we should at least start that ball rolling.

David Little: It is a question of priorities; remember that livestock have been subject to intense selection over the years in the way that wild fish populations haven't. We have got so many different strains and breeds to try and provide the farmers with germplasm which suits the needs at the moment. Surely the most effective way to conserve those genes is to make those animals more productive in the farmers' hands by putting more prioritisation on utilisation.

Qureshi: Your point is taken, but may I just mention from all that genome description work that is going on, there are some exciting developments and one outcome of it is maybe that you create that "super-rice" type of an animal which, given the same feed, produces 25% more. There this possibility.

Leng: I am not questioning at all the possibility of the research or its priority, but the priority in terms of the organisations for which we are dedicating our time. Should those organisations be promulgating conservation of species or is this something that should be taken up more by different organisations? If we take 20 million dollars out of research funds from FAO to conserve species then its a fact of life that some other pans of FAO will suffer for that reason.

# Setting priorities for agriculture research in Asia: A case study with rice

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## Abstract

The challenge for agricultural research is to balance the need for food with the need to reduce urban and rural poverty and to maintain the permanence of the resource base. The process for the allocation of resources for research on rice in Asia is used here as a case study. A modified congruence method traded productivity, equality and sustainability in the allocation of scarce resources among the major rice ecosystem—irrigated, rainfed lowland, upland and flood-prone—which dominate the Asian landscape. It is suggested that a similar approach is required for the allocation of resources for livestock systems which could include four phases of livestock–crop systems, namely the pre-intensification phase of crop–livestock independence; integrated crop–livestock systems phase; diversification of the farming enterprise phase; and the specialisation of production systems phase. The paper also discusses an ecoregional initiative for the humid and subhumid tropics of Asia that interprets among systems including those for rice and livestock.

## Introduction

To eradicate poverty and ensure a better future for the children and grandchildren of today's poor is a challenge we all share. Asia is home to the largest population of poor in the world. In 1990 more than 1.1 billion people in developing countries were living in poverty—60% of them in south and South-East Asia. Rice is their basic food. The vast majority of those who depend on rice as their staple food belong to the poorest of the poor on the bottom line of income generation, and on the bottom line of access to limited resources.

In the same Asian region, population and economic growth is changing the demand for food supplies. Rice supplies alone must increase by 70% in the next 30 years. And income driven changes will increase the demand for other food sources, including livestock products.

Any criteria that are used for determining the allocation of agricultural research priorities must be cognizant of the long term effects of rural and urban poverty as well as the changing demand for food supplies.

## People: Poverty and permanency of our resources

Within the next 15 years, more than 400 million Asians are expected to leave their villages and farms and move to the already overflowing, often unmanageable, urban centres of their countries. Rural poverty is simply transferred to the urban areas, as the migration leads to the growth of the overcrowded slums and puts extreme pressure on already limited urban resources and services. In Asia right now, 13 cities either have, or soon will have, populations exceeding 10 million. Lampe (1995) predicted that in the next century—around 2025—this migration would change the entire social structure of the Asian continent. If this

unprecedented migration is not halted, it has the potential of being not only the largest but the most explosive population shift Asia has ever experienced.

And for those that stay and struggle to feed themselves, there is no alternative but to encroach on marginal lands and begin a cycle of poverty and resource degradation that threatens the permanency of the intensive lowland food systems. Making rural life attractive and ensuring the permanence of the resource base means alleviating poverty through increasing incomes, reducing food insecurity by increasing productivity, and reducing unemployment and monotony by increasing the number (as well as the types and quality) of job opportunities.

The problem of rural misery has many roots, and it is obvious that agricultural research is not able to solve or eliminate all of them. However, technological progress has contributed significantly to alleviation of poverty in Asia, mainly by a decline in the real prices of food grains. The increases in yield, brought about by the changes of modern cereal varieties, has been quickly passed on from producers to consumers in the form of lower prices (Figure 1).

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**Figure 1.** *Trends in world rice (milled) production and price, 1953–93.*

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The challenge for agricultural research is to balance the need for food with the need to reduce poverty of the rural poor and thereby maintain the permanence of the resource base.

## **Productivity: The demand and supply of food**

Most recent developments suggest that the race to stay ahead of the food crisis is not yet over in many parts of Asia. Just to meet the projected demand for rice, the International Rice Research Institute (IRRI) estimated that the world's annual rough rice production must increase from 520 million tonnes today to at least 880 million tonnes by 2025, an increase of almost 70% (1.7% per year) over the next 30 years. Seventy per cent (70%) of that increase will need to be produced on the irrigated rice lands which are already intensively managed (Scobie et al 1993). To produce such an increase with declining arable land, reduced water resources and less rural labour input and with fewer harmful chemicals has never been done before. The additional 30% is expected from technological changes to the rice-based farming enterprises in the rainfed agriculture systems (Scobie et al 1993) where the majority of the poor live. To date, modern agricultural technology has had little impact due in part to biophysical and some economic constraints that have been well documented elsewhere (Sarma 1989; Saha et al 1994). But to date there has been little investment in research to develop appropriate technologies for these heterogeneous and variable environments. In setting research priorities, the opportunities for, and constraints to producing more food in the favourable environments (irrigation) must be balanced with those of increasing productivity of the neglected rainfed systems.

At the same time that total food needs are increasing, food habits are changing. Studies on consumption behaviour show that per capita rice intake is largely dependent on income level. At low levels, rice is considered a luxury commodity and with increases in income, people tend to substitute low cost sources of energy such as coarse grains and sweet potatoes for rice. But at high levels of income, rice

becomes an inferior good; as income rises further, consumers substitute rice for high-cost quality food, such as vegetables, bread, fish and meat. A recent study (Ito et al 1989), argues that rice has already become an inferior good in Asia, but this is only true in the four middle and high income countries that account for less than 10% of Asian rice consumption. A more recent study conducted by Huang and David (1992) showed that the threshold level of income (around US\$ 1000 per capita) at which consumers start substituting rice for other food has not yet been reached for the major rice producing and consuming countries, such as China, India, Indonesia, and Bangladesh. These four countries account for 70% of the total rice consumption and dominate the growth of food needs in Asia.

Nevertheless, income driven changes in food habits will change the per capita consumption of animal products. Rosegrant et al ( 1995), have projected per capita demand for livestock products in Asia to the year 2020 based on a recently conducted study of food supply and demand in Asia (Table 1 ).

**Table 1.** Projected per capita demand for livestock products in Asia (kg/year).

| Livestock products | South Asia |      |      | South-East Asia |      |      | East Asia (excluding Japan) |      |      |
|--------------------|------------|------|------|-----------------|------|------|-----------------------------|------|------|
|                    | 1990       | 2010 | 2020 | 1990            | 2010 | 2020 | 1990                        | 2010 | 2020 |
| Beef               | 1.2        | 1.4  | 1.5  | 2.5             | 4.5  | 6.0  | 1.3                         | 2.3  | 3.1  |
| Pig                | 0.3        | 0.4  | 0.4  | 5.5             | 8.6  | 10.5 | 18.8                        | 30.6 | 38.2 |
| Sheep meat         | 1.0        | 1.1  | 1.2  | 0.3             | 0.5  | 0.7  | 0.7                         | 1.0  | 1.2  |
| Poultry meat       | 0.5        | 0.6  | 0.7  | 4.2             | 6.9  | 8.5  | 3.0                         | 5.2  | 6.5  |
| Eggs               | 1.3        | 1.6  | 1.8  | 3.3             | 5.5  | 7.0  | 6.8                         | 10.9 | 13.6 |
| Milk               | 63.4       | 84.9 | 95.3 | 3.2             | 3.8  | 3.5  | 7.7                         | 9.3  | 10.2 |

Source: Rosegrant et al ( 1995).

Agricultural research must consider these evolving demands for food and develop technologies that enhance productivity, provide diversity, and increase profitability while caring for, and protecting the environment. In the past, too much of our agricultural research endeavour has been focused on technological changes to isolated components of a complex system without the involvement of the end user, the farmer. What is required is a systems approach to research planning and implementation which involves the farmer.

## A systems approach to agricultural research: A case study with rice

Agricultural science in many parts of the world has been shifting from a focus on food production to increased concern for natural resource conservation and environmental protection. One way to improve research relevance is to develop a more intimate understanding of the environment, production systems and problems of prospective users and beneficiaries of research results.

Many of the critical problems in rice production are specific to particular rice ecosystems. IRRI has used four main rice ecosystems—irrigation, rainfed lowland, upland and flood-prone—to focus research, with the efforts of several disciplines integrated toward solving the problems of each ecosystem. In addition to these ecosystems, IRRI focuses research in a cross-ecosystem research programme on

the development of new tools and new concepts for application in all ecosystems to meet the needs of the next generation.

The four rice ecosystems are characterised by the natural resources of water and land, and by the adaptation processes of the rice plant to them (see Figure 2). These ecosystems differ in their natural resource base, in their outputs and in their expected contribution to productivity, equity and sustainability. Thus, a challenge to agricultural research is the priority setting process that allocates resources to meet these challenges.

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**Figure 2.** *Rice ecosystems characteristics.*

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### Allocation of resources: The priority setting process

Two forces pressured the setting of priorities and allocating of resources for rice research as described in IRRI's Medium Term Plan for 1994–1998 "Rice Research in a Time of Change" (IRRI 1993):

- Balancing allocation between the needs of today and tomorrow, given current and anticipated knowledge, technology, tools and concepts.
- Allocating resources across and within rice ecosystems to meet productivity, equity and sustainability objectives.

Research prioritisation attempts to allocate available resources to maximise the returns to research activity. There are many approaches and much has been written on the various methodologies. IRRI has used a combination of approaches to allocate resources among programmes, based on rice ecosystem, and among projects within programmes.

We used our best judgment to allocate resources for new tools and new concepts to meet tomorrow's challenges. IRRI developed a cross ecosystems programme that generates new knowledge and tools that serve all rice ecosystems and allocates 29% of resources to these objectives.

We used a modified congruency method to determine priorities among the four rice ecosystems. The method is similar to that used by TAC (the Technical Advisory Committee of the CGIAR) to set priorities across commodities and regions. It involved developing a data base by country/state/province across agro-ecological zones, then estimating relative priorities on the basis of baseline parameters and modifiers that reflect IRRI's objectives for productivity, equity and sustainability.

### Baseline priorities

Baseline priorities were determined by intensity parameters, variables whose absolute values could be added across regions. The parameters selected were:

- volume of rice production (reflecting productivity)
- number of poor rice consumers (reflecting equity)
- rice area of unfavourable ecosystems (reflecting sustainability).

To make an impact on global rice production, priorities would be distributed in proportion to a country's or region's rice production. To make an impact on

socio-economic inequity and poverty, priorities would be distributed in proportion to share of global poverty.

IRRI's goal and objectives, however, are complex, and demanded adjustments among the parameters. We operationalised the number of poor rice consumers by adjusting the number of poor people in a country against the share of rice in total food grain production.

Operationalising the complex concept of sustainability was more difficult. Sustainability of food production is a major concern in unfavourable rice-growing environments where people are forced to extend cultivation on to marginal lands to meet their basic food needs. Those adverse rainfed lowlands and uplands are also most vulnerable to soil degradation. In the absence of any other suitable parameter, rice area in unfavourable rice ecosystems was used as a negative indicator of sustainability. This parameter is linked to increasing the productivity of unfavourable rice ecosystems.

Values of each parameter were listed by country/province/state across agro-ecological zones and converted into percentages of the total. Parameters were accorded equal weight and summed. The result was unmodified baseline priorities for geographical regions or agro-ecological zones.

### **Modifying baseline priorities**

Baseline priorities were estimated from static parameters reflecting historical trends; the parameters did not consider emerging trends or take into account other important factors: need for rice research, capacity of a national system to carry out research, and other indicators of equity and sustainability.

We incorporated these factors in intensity modifiers:

- High yield gaps occur mostly in countries that have variable rice ecosystems. The yield gap is due not so much to lack of opportunities for applied and adaptive research as to limited success in developing cultivars resistance to abiotic stresses. Regions with larger yield gaps were assigned higher priority.
- The capacity to undertake research depends in part on the availability of research scientists. Higher priority was assigned to countries with fewer scientists relative to population.
- Calorie intake per capita is a proxy measure of the degree of undernutrition. Using this modifier reinforced the equity concern already reflected by number of poor rice consumers.
- Average years of schooling of the female population relative to the male population was used as a proxy measure of gender disparity.
- Unfavourable rice area is inadequate for operationalising sustainability. Population growth rate, increasing and changing demand for food, food grain production, and depletion of natural resources were used as important modifiers.

Each modifier was allocated half weight and baseline priorities adjusted.

### **Priorities by region**

Modified priority estimates indicated that 54% of research resources should be allocated to addressing the problems of south Asia, 23% to South-East Asia, 14%

to east Asia, 6% to Africa, and about 3% to Latin America. The modifiers increased the priorities for south Asia and Africa largely because of higher incidences of poverty in those regions. Priorities for east Asia and Latin America were reduced primarily because of higher incomes, lower population growth rates, and self-reliance in acquiring food grains. Africa and Latin America priorities only sum to 8.4% because those continents account for only about 8% of global rice area and contribute only about 6% to global rice production.

**Priorities by agro-ecological zone**

For agro-ecological zones, the estimates suggested that the humid and subhumid tropics should be allocated 56% of rice research resources while 26% should be allocated to the subhumid subtropics and semi-arid tropics (see Table 2).

**Table 2.** *Allocation of resources for rice research by agro-ecological zones in Asia (baseline and modified priorities).*

| Zone                 | Baseline | Modified |
|----------------------|----------|----------|
| Semi-arid tropics    | 11.1     | 12.1     |
| Subhumid tropics     | 26.3     | 28.4     |
| Humid tropics        | 24.6     | 27.6     |
| Semi-arid subtropics | 1.7      | 1.3      |
| Subhumid subtropics  | 16.7     | 13.8     |
| Humid subtropics     | 10.5     | 8.0      |
| Cool subtropics      | 0.4      | 0.3      |

Source: IRRI (1993).

**Allocation across rice ecosystems**

Priorities at the regional level were allocated to the rice ecosystems according to the ecosystems share of total rice area summed across regions: irrigated, 32.2%; lowland, 21.1%, upland, 9.3%; flood-prone, 8.4%. This was adjusted to take into account cross-ecosystems research and work done by others.

To allocate resources among projects within the ecosystem programmes we used a logical framework procedure (Schubert et al 1991) to identify the constraints of primary interest and the outputs needed to reduce or eliminate the constraints. This approach draws on the knowledge, ideas and experience of team members. Thus, the composition of the planning team in terms of competence, interdisciplinarity, motivation and representativeness is of crucial importance to the outcome. IRRI involved partners from national agricultural research systems (NARS), non-governmental organisations (NGOs), and institutes from industrialised countries in the team.

The logframe approach is based on a few simple underlying principles:

- co-operation and interdisciplinary team effectiveness is smoother and more productive if all have been involved in setting priorities
- problems to be solved by research do not exist in isolation, they are intuitively linked with people, groups, and organisations

- constraints that impede the solution of a given problem are identified.

We recognise the subjective manner of this process. Thus, a number of Asian countries have been involved in a more systematic study, at the farm level, of the current constraints to rice production (Hossain and Lin 1994) with the aim of setting research priorities more objectively using a modified method of the "Crop Loss Model" (Herdt and Riley 1987). Each country is involved in the assessment of yield loss by the constraints identified, and setting their priorities for research. An example of the output of this process for the rainfed rice system for eastern India and irrigated system for China is shown in Figure 3.

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**Figure 3.** *Yield loss by constraints, eastern India and China.*

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These priority setting procedures, beginning with a congruence approach to allocate resources among ecosystems of productivity, equity and permanency and with logical framework and "Crop Loss Models" within ecosystems for research relevance and impact have guided IRRI's research on rice conducted within projects (25) and within programmes (5).

## **Allocation of resources among livestock systems**

Pingali (1993) identified four stages of crop–livestock interactions that could be used in livestock systems to allocate scarce resources for economic, social and environmental benefits, using the congruence methods described for rice ecosystems.

*Phase 1. The pre-intensification phase of crop livestock independence.* This phase is common to much of sub-Saharan Africa and to few isolated pockets in Asia. These areas are characterised by low population densities and land abundance, and shifting cultivation systems predominate.

*Phase 2. Integrated crop–livestock systems.* In the early stages of economic development, complementary linkages of draft power and farmyard manure are established with livestock production.

*Phase 3. Diversification.* Complementarities that favour the crop sector—manure and draft power—are substituted by chemical fertilisers and motor power. At the same time, increasing urban demand leads to a shift in livestock production from subsistence to greater market orientation.

*Phase 4. Specialised production systems.* The advantages of integrating the crop and the livestock sector diminishes at high levels of economic growth. Farm-produced fodder is replaced by purchased feeds. Both crop and livestock production are extremely knowledge and management intensive using minimal labour inputs. In some cases there are growing concerns about the impact on the environment of these specialised production systems.

Pingali (1993) analysed the evolution of the crop–livestock systems in Asia. Clearly the rate of change is determined by economic forces. At any point in time there will be a mixture of these phases (Table 3). The driving forces for the movement from Phase I through Phase 4 are the opportunity costs of land, labour and urban income growth. Each of the phases has varying levels of economic, social, and environmental costs and benefits. An international research initiative for

livestock should take into account these trends and the private and social benefits and costs of each stage in the process of resource allocation. This would seem a high priority activity to prioritise the technical approach to crop–livestock research. In the past the focus of IRRI's involvement, to a large extent through the Asian Farming Systems Network, has been in the technical and social aspects of phases 2 and 3. A summary of that research is provided in Table 4 and discussed in detail by Paris and Sevilla (this proceedings).

**Table 3.** Crop–livestock interactions by phase of evolution.

|                 | Crop–livestock system                                                 |                                                           |                                                   |                                                   |
|-----------------|-----------------------------------------------------------------------|-----------------------------------------------------------|---------------------------------------------------|---------------------------------------------------|
|                 | Pre-intensification phase (Independence of crop–livestock activities) | Intensification phase (Integrated crop–livestock systems) | Income diversification phase                      | Specialisation phase                              |
| Power source    | Human                                                                 | Animal                                                    | Motor                                             | Motor                                             |
| Soil fertility  | Fallows                                                               | Farmyard manure                                           | Chemical fertilisers                              | Chemical fertilisers                              |
| Fodder          | None                                                                  | Crop residues                                             | Crop residues                                     | Purchased feed                                    |
| Human nutrition | Hunting/ gathering                                                    | Subsistence production of animal products                 | Commercial production of crop and animal products | Commercial production of crop and animal products |

Source: Pingali (1993).

## An ecoregional approach to research

TAC's concept of an ecoregional approach is that of a strategy for bringing a new balance to international agricultural research to enhance the sustainable improvement of productivity, and for gradual transition in the organisation of the global agricultural research system to meet the sustainable challenge.

TAC sees three aspects of the ecoregional approach to research:

- conducting applied and strategic research on the foundations of sustainable production systems
- improving productivity in the ecoregion by drawing in appropriate global research activities
- strengthening the co-operation with national partners and developing transitional mechanisms for collaboration .

TAC also states, "The global community does not yet have an effective paradigm for the sustainable improvement of productivity".

TAC has identified agro-ecological zones (AEZs) as ecosystems defined regionally. The major AEZs are given in Table 5. IRRI has developed a "framework" for an 'Ecoregional Approach to Research and Development in the Humid Subhumid Tropics and Subtropics of Asia'. The ideas, concepts, partners and mechanisms for the ecoregional approach to research for development are evolving. Of most significance for the initiative are the strong consortia and networks that are now managed by NARS of the region. We now intend to further refine these by extending the scopes of our approach to include issues that cut across and within the four AEZs in a geographic mode, i.e. ecoregional mode.

Initially, we will focus on the most critical zones and those where rice predominates. TACs congruence analysis of ecoregional zones world-wide is shown in Table 6. AEZs 2, 3, 6 and 7 are of crucial importance worldwide, and as such will be the focus of our ecoregional initiative.

**Table 4.** *Livestock-related research conducted at IRRI by year (1967 to 1988).*

| Year | Study                                                                                                                                                                 | Department in charge                                |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| 1967 | Economic survey of central Luzon on the use of carabao (water buffalo) in rice production                                                                             | Agricultural engineering and Agricultural economics |
| 1974 | Economic studies on land preparation techniques                                                                                                                       | Agricultural engineering                            |
| 1975 | Tillage methods at rainfed (lowland and upland) and partially irrigated rice areas                                                                                    | Multiple cropping                                   |
| 1976 | Power tiller and water buffalo owners' survey                                                                                                                         | Agricultural engineering                            |
| 1984 | On-farm research interventions in livestock management                                                                                                                | Rice farming systems programme (RFSP)               |
| 1985 | Dual-purpose food–forage cropping systems and forage crop management                                                                                                  | RFSP                                                |
|      | Animal health management study                                                                                                                                        | RFSP                                                |
|      | Multiple uses of livestock study                                                                                                                                      | RFSP                                                |
|      | Rice straw utilisation study                                                                                                                                          | RFSP                                                |
|      | Fodder trees and shrub study                                                                                                                                          | RFSP                                                |
| 1986 | Breeding by artificial insemination                                                                                                                                   | RFSP                                                |
|      | Study on the evaluation of forage crops in Sta. Barbara, Pangasinan, the Philippines                                                                                  | RFSP                                                |
|      | Compilation of data on digestibility and energy values of various fodder crops, fodder tree browse, grasses, field legumes and crop residues                          | RFSP                                                |
| 1987 | Evaluating forage crops in the lowland and upland and on food storage production systems in Sta. Barbara, Pangasinan (lowland) and in Trece Martires, Cavite (upland) | RFSP                                                |
| 1988 | Component technology research on forage crops and proper cultural practices to increase animal feeds in rice-based farming systems                                    | RFSP                                                |

Sources: IRRI Annual Reports (1967, 1974, 1976, 1984, 1985, 1986, 1987, 1988).

**Table 5.** *The major agro-ecological zones.*

| Agro-ecological zone | Regional definition                                  |
|----------------------|------------------------------------------------------|
| AEZ 1                | Warm arid and semi-arid tropics                      |
| AEZ 2                | Warm arid subhumid tropics                           |
| AEZ 3                | Warm humid tropics                                   |
| AEZ 4                | Cool tropics                                         |
| AEZ 5                | Warm arid and semi-arid tropics with summer rainfall |
| AEZ 6                | Warm/cool subhumid subtropics with summer rainfall   |
| AEZ 7                | Warm/cool humid subtropics with summer rainfall      |
| AEZ 8                | Cool subtropics with summer rainfall                 |
| AEZ 9                | Cool subtropics with winter rainfall                 |

Source: CGIAR (1994).

**Table 6.** *Distribution of relative priority indices by AEZs and geografhic regions, with agriculture.*

| Consolidated AEZs                                                             | SSA   | WANA | Asia  | LAC  |
|-------------------------------------------------------------------------------|-------|------|-------|------|
| Warm arid and semi-and tropics and subtropics with summer rainfall (AEZs 1+5) | 136.8 |      | 12.1  | 23.7 |
| Warm subhumid tropics and suhtropics with summer rainfall (AEZs 2+6)          | 68.2  |      | 64.4  | 39.9 |
| Warm humid tropics and subtropics with summer rainfall (AEZs 3+7)             | 98.6  |      | 148.2 | 73.7 |
| Cool tropics and suhtropics with summer rainfall (AEZs 4+8)                   | 33.1  |      | 63.6  | 42.0 |
| Cool subtropics with winter rainfall (AEZ 9)                                  |       | 81.1 |       | 5.8  |

Source: CGIAR (1994).

The relative importance of commodities within these zones, is shown in Table 7. Rice predominates, but other crops and livestock play an important role. Since rice accounts for 90, 77, and 71% of total food grain production in AEZs 7, 2, and 3, respectively, increasing rice productivity will substantially affect the livelihood of farmers and consumers But the diversity of the farming systems, including livestock, provides for greater farm income and for more sustainable resource management practices. An effective ecoregional initiative requires the integration of the various international centres and NARS working in these enterprises.

Since rice is such an important component, we plan to use a rice-based landscape as model to focus our research activities (Figure 2). Within that landscape, determined by water availability and its use by rice, we plan to focus the ecoregional initiative on optimum land use systems for productivity and sustainability of the water resource of Asia. A key component of this research is the development of models that allow decision at all levels of integration—from the genome to the crop to ecosystem and to the regional level. This concept of production ecology integrates knowledge of the basic processes in living production systems in such a way that sustainable land use and natural resource management responds to well-defined socio-economic, ecological and agricultural objectives and constraints (Figure 4).

**Figure 4.** *Interrelationships among major levels of research complexity.*

## Conclusion

The most promising avenue to sustainable agricultural development is continuous growth in productivity through new technologies. Higher yields and profits on fertile and environmentally safe land will reduce the pressure on fragile lands for growing more food (and obtaining fuel) and will halt further deforestation and soil erosion.

Poverty alleviation itself is considered an indispensable element of sustainable development (WCED 1987). Where land is scarce (in Asia) population pressure is high, and physical survival of the people is at stake. Poor households are forced to meet their immediate needs in ways that lead to continuing loss in rural and urban

resources. Agricultural research can take up the challenge to provide an adequate supply of food at affordable prices to the poor using fewer environmental resources, and by providing enterprises that increase opportunities for rural income generation. This research is not a simple matter, but must deal with a number of exceptionally difficult problems in a systems context. The speed and extent of meeting these challenges depend on the level of resources, how well they are allocated, and how effective we are in co-ordinating our national and international efforts.

**Table 7.** *Relative importance of commodities by agro-ecological zone (AEZ) in Asia.*

| Commodity             | Agro-ecological zone <sup>1</sup> |            |
|-----------------------|-----------------------------------|------------|
|                       | (AEZs 2+6)                        | (AEZs 3+7) |
| Rice                  | 309.5                             | 846.1      |
| Wheat                 | 27.3                              | 37.9       |
| Maize                 | 21.1                              | 69.7       |
| Barley                | 1.6                               | 0.0        |
| Sorghum               | 8.1                               | 0.1        |
| Millet                | 9.4                               | 0.3        |
| Cassava               | 26.4                              | 72.3       |
| Potato                | 13.3                              | 27.7       |
| Sweet potato          | 20.6                              | 73.5       |
| Yam                   | *                                 | 0.9        |
| Banana and plantain   | 27.9                              | 58.4       |
| Chick pea             | 9.0                               | 1.1        |
| Cow pea               | 0.4                               | 0.3        |
| Pigeon pea            | 5.4                               | 0.0        |
| Broad bean            | 1.3                               | 3.4        |
| Lentil                | 1.8                               | 2.9        |
| Beans                 | 5.8                               | 5.8        |
| Soybean               | 10.6                              | 27.0       |
| Groundnut             | 48.7                              | 24.5       |
| Coconut               | 13.7                              | 131.9      |
| Beef and buffalo meat | 17.2                              | 52.0       |
| Sheep and goat meat   | 6.4                               | 14.3       |
| Milk                  | 88.9                              | 25.2       |
| Total (%)             | 6.7                               | 14.8       |

1. AEZs 2+6 signifies the warm subhumid tropics and subtropics with summer rainfall; AEZs 1+7 signifies the warm humid tropics and subtropics with summer rainfall.

\* Value <0.5.

Source: CGIAR (1994).

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## Discussion following Dr Fischer's paper

Carroll: I and the Bank are pleased to see that ILRI has in fact become an entity and the purpose of this consultation for the South-East Asian region is to look at the livestock research issues of global importance as they relate to this particular area of the world.

I am very concerned as I believe all of us are aware of the very alarming trends and indications that there are in the world food supply. The world food stocks are currently at the lowest they have been for 20 years, and in the last three years we had a net food deficit. This is alarming especially when you look at the graphs that Ken Fischer showed. It is becoming more difficult to increase the yields or to even sustain the current yields. This is also true for wheat and there are some very alarming examples of what is happening in Pakistan and some other countries where rather than increasing yields they are declining on the irrigated areas. And again as Ken pointed out, we can look at production from the dry land or rainfed areas. But, most of the increased production for rice, in particular, and probably for wheat and other crops, is going to have to come from the irrigated areas. But these are declining. The amount of arable land available for cropping is declining year by year, much of it due to urbanisation but also of course due to pollution and other problems.

But coming back to livestock. Livestock, unfortunately (using the examples of the ADB and the World Bank too), have been given a back seat in the last few years because a lot of people, I believe quite wrongly, have blamed livestock for many ills in agriculture. Certainly some Bank staff and economists regard livestock as being one of the bete noirs of agriculture. It is becoming more difficult to get finance for livestock and hopefully this will be turned around. Many of us are fighting very hard to put things into a proper perspective and you cannot have, I believe certainly in Asia, rice production or wheat production without livestock. Livestock form the basis—the underpinning agent—that enables the production of rice and wheat and other crops in Asia. Land tenure issues and the problems of fragmentation of land virtually rule out the use of mechanisation in many areas.

So livestock will continue to play a very important role in agricultural production and in rice production and other crop production for a long time to come. Nutrition of our livestock, particularly the draft animals and the milking animals which are very important in South Asia and other parts of Asia, has become a major problem, and one that is, I believe, caused by the decline in availability of dry matter. Farmers traditionally used a lot of straw, but the quality of paddy straw available for livestock feeding has declined.

My question to Ken Fischer was, if this new high-bred strain of tropical Japonica with its greater yields (and you showed the photograph of the much stronger stems) has a high silicon content, will its digestibility for ruminants be even lower than before?

Fischer: I can't answer, I think that the point I was making was that there will be proportionally more of the total energy in grain. We have not

begun examining other aspects about its quality and I think that these are the areas that will need attention. I think that one also should take note that the target area for these high yielding rice plants may be relatively well described in terms of the direct-seeded rice systems in which they are developed, and for the high inputs that will be required to drive the high yields.

- Leng: We have a perfectly good forage in rice straw that can now outproduce good temperate pastures provided we have the right supplements. It really doesn't matter much if the quantity of straw goes down because if we use it more efficiently we can produce now with known technologies, at least four times from the available resources.
- Qureshi: Mr Chairman you mentioned the problems with mechanisation that are reducing the yield gap. It is also a fact that animal power is used for 98% of the farms. A project in Cambodia showed that just better feeding of draft buffaloes on straw-based diet has improved ploughing and increased the rice yields. My question to Dr Fisher is what's the thinking in rice circles about this issue? With improvement in draft animal power considered as an important factor in reducing this yield gap there may be just better animal management and also better implements affecting these areas.
- Hossein (IRRI): To answer your question frankly, we have not given very serious thought to that issue of the substitution of mechanical power for draft power. But in many countries of Asia, even in countries in south Asia which are predominantly dependent on draft power from cattle, we see increased trends of mechanisation particularly use of small-scale tillage, multi-purpose kind of tillage. There has been a spread of small-scale irrigation technology.
- Fitzhugh: Ken, you presented a slide which indicated your projections are that the absolute number of the rural population will decrease over the next 30 years or so. What do you expect this to do to land holdings and to the cultivation practices? Will this cause a move to a larger holding, more mechanisation or continued fragmentation of holdings and therefore less mechanisation?
- Fischer: I think the broad picture is that there are large changes taking place in the way that rice is being produced in many countries where there is demand for labour in the urban areas. One of the biggest changes is moving away from transplanted rice to direct-seeded rice and that's occurring very rapidly. There are changes in mechanisation aspects that are linked with that change in rice culture. So I think that without being able to get into details there certainly are rapid trends in mechanisation taking place, driven by labour or cost of labour changes in many of the countries in the region.
- Hossein: We could look also at the examples of Japan and South Korea which have already gone through that transformation of urban expansion etc. And we didn't see much of the consolidation of holdings which should have taken place as a result of rural-urban migration. What is happening is that the elders or the women members of family are taking care of the small farms. It might be because of the very high

value of land in rural areas and it's not possible to transfer that land because of that high value. So commercial enterprises are being developed which are providing mechanisation services to a large number of households who own small-sized holdings. Increasing the size of holding in Asia, I think, is a problem related to the very high price of land in Asian countries.

Doug Little: Ken, you indicated that you saw proportionately more potential in improving the upland rice. I wonder if you could expand on how you see this happening: better varieties, more intensification, extra areas etc?

Fischer: I think there are two issues. One is that there are opportunities, we believe, in the rainfed systems for increasing output. We believe that we have not focused attention on those variable and heterogeneous systems in terms of rice. There are new tools and biotechnologies that allow us to get our hands on some of the issues about rice production in those systems. Then, secondly, by allocating more resources to addressing the systems and looking at opportunities for smart release of nutrients and for changing the profile of those systems; direct seeding of rice, for instance, has made tremendous opportunities in allowing different windows for farmers to diversify their systems. So it is in the rainfed systems that we see the need; we are fairly optimistic about technology that can help in those areas. I mentioned the uplands only in as much as rice is a small component of those enterprises, but we all understand their importance to the long-term sustainability of the food systems and the real need to look for ways of integration and diversification as a means for enhancing livelihood and, in the long term, to address the issues of sustainability of the resource base of the low lands.

# Priorities for socio-economic research in farming systems in South-East Asia

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## Abstract

Experiments conducted on-station and on-farm for the alleviation of various constraints to animal production—such as acute shortage of animal fodder—indicated that most of these technologies were technically feasible, but that farmer adoption was relatively low due to socio-economic reasons. Some of the major socio-economic reasons were (a) declining trends in draft animal usage particularly because of mechanisation; (b) higher off-farm wage rates and opportunity costs of family labour; (c) unfavourable government agricultural policies for smallholder livestock development; (d) unavailability of required inputs and support services; (e) risk aversion; (f) inadequate training and extension for knowledge-intensive technology and lack of credit to the poor without collateral. Socio-economic research priorities in crop–animal research are (a) to review the past research conducted by NARS and identify priorities for further research; (b) farmer participatory research on dissemination of proven technologies in similar agro-climatic and socio-economic environments to increase research utilisation; (c) examination of the effects of macro-economic policies in relation to adoption of improved livestock as well as the changing trends from subsistence to commercialisation; (d) study of farmers' practices, knowledge, attitudes, perception and decision-making processes and the incorporation of women's concerns in technology design, testing and evaluation of technologies; (e) more emphasis on ex-ante analysis of technologies; (f) systems simulation and modelling of crop–animal systems and, (g) evaluation of the impact of crop–animal integrated technologies.

## Introduction

In humid and subhumid Asia, rice is the staple food and principal crop. It accounts for 30–50% of agricultural incomes and provides 50–80% of the calories consumed by the people (Hossain 1994). About 57% and 43% of the total rice area in Asia are under irrigated and rainfed conditions, respectively (IRRI 1993). Rice yield has remained low in the rainfed lowlands (2.3 t/ha) and uplands (1.1 t/ha) compared with the yields in the irrigated ecosystem (5 t/ha). Crops grown in the rainfed lowlands and uplands are highly dependent on the amount and duration of rainfall. In these rainfed areas, agricultural lands in general are acidic and subjected to soil erosion and degradation; they are therefore low in fertility. Hence, the smallholder farming system in Asia is near subsistence, resulting in pervasive poverty in the rural areas.

Due to the low and uncertain level of crop productivity in these environments, animals form an integral and important component of the farming system. Thus, it

is in the rainfed lowland and upland systems where there is a particularly strong interaction between crop and animal subsystems. While these areas are environmentally fragile, they have great potential for agricultural and socio-economic development. These areas are not only biologically diverse, but are also characterised by a wide array of socio-cultural structures and beliefs, which directly and indirectly influence animal production.

Thus, this paper will attempt to identify some socio-economic constraints to animal production and suggest socio-economic research priorities/strategies to optimise animal production in the smallholder farming systems of Asia.

## **The importance of animals in farming systems in Asia**

Animal production is an integral part of crop production in Asia. The two are interdependent since Asian agriculture is characterised by mixed farming. The practices in such crop animal systems are very complex and vary depending on the physical, biological, and socio-economic parameters (Carangal 1995). Large ruminants provide draft power and animal manure for crop production while crop residues and crop by-products are important sources of animal feeds. Large ruminants are also raised as forms of savings and hedge against risks. Sale of livestock and poultry and their products are used to improve and stabilise farm income for the purchase of cash inputs and to offset household expenditures such as school fees, social obligations and health care. Swine, goats and poultry, raised mostly by women, are immediate sources of cash, forms of social security, insurance, personal investments, and sources of funds for school fees, family health care costs, dowry and other household expenses.

In many Asian and South Pacific societies, farmers raise animals for social reasons. Small animals and poultry are used to seal social contracts such as marriage, kinship ties and friendship. Chickens are a popular form of sacrifice for rituals in animistic and some institutionalised religions, in which case the colour of the plumage may be significant. However, in some countries there are cultural and religious practices mitigating against certain aspects of livestock development, and these must be understood and respected. Buddhist strictures against the killing of animals, Moslem and Jewish taboos regarding swine and other scavenging animals, Hindu veneration of the cow, and the vegetarian's attitude to animal foods are reasons for not promoting certain livestock production. Ownership of animals is also a measure of a family's social and economic standing (RAPA 1990a).

Understanding these crop–animal interactions, and the social and economic reasons why farmers raise animals in specific agro-ecosystems, will help scientists design farming technologies which will not only improve animal production but, more importantly, ensure a higher rate of adoption.

## **Crop–animal systems research under the Asian Rice Farming Systems Network**

The importance of livestock in smallholder farming systems, particularly in rainfed environments, was given explicit attention at IRRI when cropping systems research expanded to farming systems research with the inclusion of the animal component of smallholder farms in Asia. Thus, in 1983, the name of the Asian Cropping Systems Network (ACSN) was also changed to Asian Rice Farming Systems

Network (ARFSN) with support from the International Development Research Centre (IDRC).

In 1984, ARFSN initiated collaborative research both on-station and on-farm with selected countries in Asia. The aim was to develop appropriate technologies and methodologies for conducting crop–animal systems research in irrigated, rainfed lowland and rainfed upland rice ecosystems. On-farm research was initiated in five key research sites in four countries representing different rice ecosystems (Table 1). The existing team of crop researchers and socio-economists was expanded to include animal scientists, forage agronomists, veterinarians etc to conduct an integrated approach to solve farmers' problems, particularly in rainfed rice environments. Recommended strategies in food–forage production systems are given in Table 2.

**Table 1.** *The crop–animal farming system key sites indicating the location of crops, trees and animals involved in the study.*

| Location                                      | Rice ecosvstem           | Crops and trees                                                                            | Animal                             |
|-----------------------------------------------|--------------------------|--------------------------------------------------------------------------------------------|------------------------------------|
| 1. Phumdi Bhumdi, Nepal                       | Rainfed lowland midhills | Maize, wheat, rice, mustard, oats, millet, Napier and fodder trees                         | Bufalalo                           |
| 2. Changping, Beijing, China                  | Irrigated                | Rice, rye, maize, tritcale and wheat                                                       | Dairy cattle                       |
| 3. Ban Phai, Khon Kaen, Thailand              | Rainfed lowland          | Rice, maize, cassava, peanut, mungbean, grasses and stylo                                  | Beef and dairy cattle and cow/calf |
| 4. Batumarta, South Sumatra, Indonesia        | Rainfed upland           | Rice, cassava, maize, soybean, peanut, mungbean, coconut, rubber, forage crops and grasses | Cattle, goats and chickens         |
| 5. Santa Barbara, Pangasinan, the Philippines | Rainfed lowland          | Rice, mungbean, cowpea, Leucaena, Sesbania and forage legumes                              | Cattle and pigs                    |
| 6. Magallanes, Cavite, the Philippines        | Rainfed upland           | Rice, maize, cassava and cowpea                                                            | Cattle, chicken and pigs           |
| 7. Zhenjiang, Jiangsa, China                  | Irrigated                | Rice, wheat, barley, vegetables and rapeseed                                               | Pigs                               |

**Table 2. Recommended strategies in food–forage production systems.**

| Ecosystem              | Proposed on-farm experiment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Irrigated lowland rice | <ul style="list-style-type: none"> <li>• Evaluate different cropping patterns involving rice–food + forage legume production system.</li> <li>• Use forage crops adapted to the environment</li> <li>• With good irrigation during dry season: <ul style="list-style-type: none"> <li>• evaluate a rice–food crop–food crop where forage legume is intercropped in the first food crop</li> <li>• grow forage legume until the planting of the next rice crop</li> </ul> </li> <li>• Introduce a fast growing forage species as relay crop in standing transplanted Aman rice or between winter rice–transplanted Aman</li> <li>• Evaluate growing grasspea/fieldpea/sunhemp as relay crops in transplanted Aman and Dhincia grown before transplanted Aman</li> <li>• In areas with two rice crops grow a third crop of food-forage between the two rice crops rather than forage crops</li> <li>• In temperate environments, such as north China and Korea, evaluate forage crops after rice, e.g. triticale, rye, Italian rye grass etc</li> </ul> |
| Rainfed lowland        | <ul style="list-style-type: none"> <li>• In monocrop transplanted Aman area, evaluate grass pea and blackgram as relay crops after rice and mungbean plus <i>Sesbania</i> before rice</li> <li>• After rice, intercrop berseem with wheat in subtropical countries</li> <li>• In tropical environments, evaluate food plus forage legume intercropping after rice during the dry season using early maturing food legumes such as mungbean and cowpea and drought tolerant forage legume such as <i>Siratro</i>, stylo and <i>Crotalaria</i></li> <li>• In areas with more than 0.5 m water depth, evaluate rice varieties that can be harvested for forage from 50–80 days after planting and then grow to maturity for the grain crop</li> <li>• Relay crop of forage on standing deepwater rice, e.g. grasspea/field pea, blackgram</li> </ul>                                                                                                                                                                                                     |
| Upland                 | <ul style="list-style-type: none"> <li>• With limited rainfall and one main rice crop: <ul style="list-style-type: none"> <li>• main cereal crops intercropped with forage legumes such as stylo, <i>Siratro</i>, <i>Pueraria</i> and <i>Clitoria</i></li> <li>• main cereal crops intercropped or relay cropped forage legumes</li> </ul> </li> <li>• With good rainfall and two crops with forage legumes: <ul style="list-style-type: none"> <li>• main cereal crops during the first crop followed by food legume plus forage legume intercropping</li> <li>• main cereal crops intercropped with food legumes followed by food legume plus forage legume intercropping combination of the two every other year</li> </ul> </li> </ul>                                                                                                                                                                                                                                                                                                            |
| Upland hilly areas     | <ul style="list-style-type: none"> <li>• Alley cropping using cereals (millet, maize, sorghum, upland rice etc) or food legumes (soybean, mungbean, blackgram, peanut etc) and alley crops species (pigeon pea, <i>Sesbania</i> spp, <i>Flemingia</i>, <i>Gliricidia</i> and <i>Desmanthus</i>)</li> </ul> <p>In areas with good rainfall, add crop between the alley crop after harvesting the cereal crops</p> <ul style="list-style-type: none"> <li>• Use forage grass or legumes as alley crops in the contour, e.g. Napier, hybrid Napier, <i>Setaria</i> etc</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

Non-cropping  
land

- Grow food crops (cereals and legumes) between the alley crops
  - Use trees (fruit trees, coffee etc) in the contour with forage legume (stylo) or grass (*Setaria*) between the trees in the alley
  - Grow food crops (cereals and legumes) between the contour or alley
  - Rice bunds: evaluate *Sesbania*, *Clitoria*, *Desmanthus*, pigeon pea, and lorage grasses such as Napier, *Setaria*, hybrid Napier etc
  - Farm boarder: evaluate *Leucaena*, *Desmanthus* and *Gliricidia*
  - Homestead area: planting of multi-purpose fast growing tree species around the homestead, such as *Leucaena*, jackfruit, *Sesbania* spp, *Albizia* etc
  - Roadsides, embankments, highways and railways should be covered with appropriate fodder/forage species
- 

A farming systems perspective was adopted in the technology development process. Although there are different modifications in different countries in implementing this systems approach, the basic components are the general methodology for farming systems research and its steps in diagnosis, design, evaluation and transfer of technology have been followed in animal production with modifications (Carangal 1993; Calub et al 1988; Calub et al 1993). The highlights and contributions of the ARFSN to crop–animal systems research have been documented by Carangal and Sevilla (1993).

## Socio-economic constraints to animal production

Several studies (IRRI 1986; IRRI 1990; IRRI 1993) identified common problems in animal production in Asia. These include acute shortage of animal fodder, particularly during the dry season, low productivity/performance of animals, low nutritive quality of crop residues, and animal nutrition and health-related problems.

To address these constraints on-station and on-farm experiments were conducted in several countries in Asia: China, Indonesia, the Philippines, Thailand, Vietnam, Nepal, India and Myanmar. The technologies involved ways to improve the quantity and quality of animal feeds by improving the cropping systems in different rice ecosystems. Based on the crop–animal systems research experiences, the technologies to improve animal production were found to be technically feasible. However, in spite of numerous demonstrations through research and the potential benefits of mixed crop–animal farming systems, technology adoption had been relatively low. In many instances the low adoption rate was due to socio-economic reasons. Generally these socio-economic reasons are:

1. The declining trend in draft animal usage particularly in irrigated and favourable lowland rainfed areas due to the shift to small-scale mechanisation

Studies on the effect of rice bran supplementation on draft capacity, draft usage, and improvement of the utility of draft animals and how these can contribute to sustained farm productivity were conducted in the favourable, rainfed village of Sta. Barbara, Pangasinan, the Philippines. However, with the increasing use of power tillers for land preparation, draft animals are used only for light work such as hauling or transporting farm products instead for heavy work (ploughing). With growing economic prosperity and rising wage rates in Asia, carabao and cattle will be used more as a source of milk and meat and less as a source of draft power.

## 2. Higher off-farm wage rates and opportunity costs of family labour

As economic development takes place, there is a general withdrawal of labour from the agricultural sector to the industrial and urban sectors (Pingali 1993). With increasing opportunity costs of family labour, especially male labour, labour intensive activities with low returns have low potential for adoption. For example, to increase the profitability of backyard swine production, on-station and on-farm experiments in Cavite, Laguna, the Philippines, were conducted using home-grown crops such as cowpea, cassava or sweet potato as ingredients in the feeding ration. While on-farm experimental results were encouraging, this technology was not adopted due to the rapid industrialisation of the province which was not anticipated when the project was initiated. Similarly, in Khon Kaen, Thailand, the migration of men affected the adoption of forage grasses as a teeding intervention for cattle fattening. Male family members, who have greater opportunities for non-farm employment, leave the care and management of animals to female family members (Paris 1993).

## 3. Unfavourable government agricultural policies for smallholder livestock development

Macro-economic policies affect the adoption of mixed crop–animal technologies at the farm level. Policies such as overvalued exchange rates which encourage the importation of livestock products discourage local producers from growing local feeds. High interest rates also discourage the long-term investments required in many animal production systems, particularly cow–calf operations and dairying.

Policies which promote the use of modern, internationally tradeable agricultural inputs rather than the non-tradeable traditional inputs (e.g. the crop residue, pasture, manure and draft power advantages in crop–animal farming) encourage the separation of crop and livestock.

## 4. Unavailability of required inputs and support services

Improved technologies require inputs which are often inaccessible, unavailable at the right time or are unaffordable to poor farmers. Selected introduced forage species identified as being suitable for food/forage integration were evaluated at the IRRI experimental farm and in a few farming systems key sites in the Philippines and in Myanmar (Tengco 1995). On-farm experiments on mungbean and siratro intercropping showed potential for producing food and fodder in limited lands; however, the sustainability of this system depends on the availability of siratro seeds. To sustain farmers' interest in growing siratro, there should be farmers who are willing to grow and sell seeds as well as supply the other farmers. The unavailability of molasses and mineral mixtures for urea–molasses block licks also discourages farmers from adopting this technology. Artificial insemination schemes have been tried but were not adopted due to the difficulties in making use of the service. Raising improved poultry breeds requires stock and vaccination services which are not readily available in some communities.

## 5. Risk aversion, perceptions

Many of the proposed interventions are not adopted due to farmers' perceptions and the reduced emphasis on the economic benefits from animals. To increase the protein quality of animal feeds, leguminous trees such as *Leucaena* and *Gliricidia* were introduced as feeds for ruminants. However, aside from the problem of psyllid infestation, farmers were reluctant to use these leaves to feed their cattle because of a misconception that these leaves would precipitate abortions in

pregnant cows. There was a lack of knowledge regarding the difference between the digestive system of the ruminant and non-ruminants.

One of the reasons for low adoption of forage crops despite the availability of technologies, is farmers' perceptions. For example, farmers in north-east Thailand raise animals for draft and as a form of savings. Farmers are not concerned with technologies such as growing forage grasses, which will increase the weight of their draft animals, as long as the animals can plough and haul and can be sold at any time. Farmers do not see the benefits of providing better quality feed to these animals, and do not think it is worthwhile putting in the extra effort to grow forage crops.

Farmers are hesitant to go into cow calf operations because of the long pay back period, and because smallholder cattle often show a delay in the first calving and have long calving intervals. However, on-farm experiments in Sta. Barbara, the Philippines, demonstrated the technical feasibility and profitability of improved cow calf management (protein supplementation, creep teeding and early weaning of calves). Results of such experiments should be further replicated in other similar socio-economic conditions and agro-ecosystems to encourage more farmers to adopt this technology (Sevilla 1995).

#### 6. Inadequate training and extension for knowledge-intensive technology

Despite the nutritional advantages of treating straw with urea, adoption is low mainly because farmers do not have adequate training and knowledge of the proper utilisation of the technology. For example, as a supplement to cattle ration, or for treatment of straw, farmers need to fully understand that if urea is used in the right amount the chance of toxicity is nil.

#### 7. Lack of credit to the poor without collateral

Improved breeds of poultry (e.g. crossbred between native males and Rhode Island Red females in Chiang Mai, Thailand; F<sub>1</sub> offspring of native chicken crossed either with New Hampshire or White Cornish breed in Matalom, Leyte; or Star Cross Brown in Sreepur, Bangladesh) were introduced with improved management such as feeds, confined housing, artificial incubation, tendering and marketing, vaccination and the use of artificial brooders for day-old chicks in key sites in the Philippines, Bangladesh and Thailand (Alcober 1991; Banu et al 1991; Shinawatra et al 1991). Although the interventions contributed to income and family nutrition, these were not sustainable for farmers who lived away from markets, who could not afford to buy supplemental feeds and where traditional technologies were found to be more efficient. Lack of credit, particularly for those who do not have collateral, often constrains improved poultry raising ventures.

In Bangladesh, the Grameen Bank provided women from landless and resource poor families with access to credit for livestock and poultry production without collateral. The proportion of the total loans to female borrowers in livestock (milk cow raising and cattle fattening), poultry and fisheries increased from 42.8 to 54.9% from 1979–83 to 1986. The repayment performance was best for women borrowers—81% of them had no overdue instalments, compared with 74% from men (Hossain 1988). In Batumarta, Indonesia, successful revolving credit schemes for women's groups encouraged women to improve the management of Peling (native breed). This contributed to the sustained adoption of the intervention (Supriadi et al 1991). Moreover, improved poultry breeds require intensive management, skills and time of women which have to be considered in technology design.

# Socio-economic research priorities in crop–animal systems research

With the described socio-economic constraints to adoption of integrated crop and animal technologies, the following are suggested as socio-economic research priorities in crop–animal systems research in South-East Asia.

1. Review of past research conducted by NARS and identify priorities for further research

For the past 10 years, numerous studies on crop animal production systems have been conducted by NARS and with IRRI's upland research consortium. We should learn from past experience and identify which of these technologies need to be tested under similar environments using a farming systems perspective. On-farm research for incorporating food storage legumes in the rainfed rice-based farming systems should be continued. On-farm experiments using grasses and leguminous plants as animal feeds and organic fertiliser should be conducted in upland rice environments in Laos, Cambodia, Vietnam and Thailand taking into account physical, biological and socio-economic factors. Increased utilisation of homestead lands for the production of forage should be explored further.

2. Farmer participatory research on dissemination of proven technologies in similar agroclimatic and socio-economic environments to increase research utilisation

Community-based service schemes such as revolving credit funds, animal sharing systems, smallholder banks for forage seeds, parent stock for poultry and other stock, and vaccination services should be explored to help smallholder farmers move from subsistence to semi-commercial production. This will require links with development NGOs and extension workers, particularly in the communication of information. Since women play important roles in livestock management, particularly of small animals, appropriate methods of extension to reach women should be given greater attention.

3. Examination of the effects of macro-economic policies in relation to adoption of improved livestock and the changing trends from subsistence to commercialisation as a result of economic prosperity and rising wages

Economists can play an important role in examining the effects of macro-economic policies as influenced by GATT in relation to livestock development.

4. Study of farmers' practices, knowledge, attitudes, beliefs, perceptions and decision making processes and the incorporation of women's concerns in technology design, testing and evaluation of technologies

5. Provision of more emphasis on ex-ante analysis of technologies

Due to the risks involved in introducing feeding interventions, it is important for economists to conduct ex-ante analyses of interventions recommended by animal scientists. Will the proposed interventions require more labour, land and capital? Livestock scientists are rarely trained to consider the important economic variables influencing the supply/demand for new technology. This often results in generating technology for a specific group of farmers, under a narrowly defined technology scenario.

## 6. Systems simulation and modelling of crop–animal systems

A lot of resources and effort can be saved if we are able to predict the more likely outcome of a particular technology within a very complex system such as the smallholder farm. Systems analysis should be used to better understand how various resources are allocated within a farming systems

## 7. Evaluation of the impact of integrated technologies for crop–animal improvement

While much research has been conducted over a period of years, the evaluation of impact in terms of changes in income, work-load of men and women, family nutrition and the effect on the environment is necessary. Technologies should not only be technically feasible and economically viable but socially acceptable and environmentally friendly.

# Conclusions

Adoption of technologies for crop–animal integration will depend on the specific agroclimatic and socioeconomic conditions under which farmers live. The linkage between crops, draft power and manure will disappear in areas where wages and opportunity costs of labour are increasing (Pingali 1993). The potential for adoption of food–forage production systems will be high in areas where farmers realise the benefits to such enterprises as cattle production, fattening and dairying. While scientists are concerned with increasing food and income for smallholder families through technologies which improve the integration of crop and animal subsystems, economic development which will contribute to the disappearance of these complementarities should be anticipated. International and national research efforts to help smallholder farmers through research should continue. However, unless government policies will provide the farmers with incentive and support services, they will be resistant to any interventions proposed by scientists.

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# Discussion following Drs Paris and Sevilla's paper

Carroll: There is a tendency for all of us technicians to concentrate on technical matters, the scientific and technical issues which we have all been trained to follow through in our University days, and we tend to have a fairly narrow view, perhaps, of an approach to development. And this, I believe, gives rise in many cases to a tendency for development efforts to be directed far too much to the technicalities without taking into account what those technicalities are for—the people. So I am pleased we have been able to concentrate on the "people" aspects of technology adoption.

Dr Paris also mentioned the need for closer liaison between the farmer at the grass roots and the research worker, a point I would like to emphasise and I think ILRI should also be considering (if I may be so bold to say so), not just research of technicalities but we need perhaps to do a bit of research into the methodologies for linking the problems at the grassroots with the sort of research that is done. The way in which the information flows take place between the farmer—who is obviously the recipient of the technology—and the people who carry the information from him to the research worker is similarly important. Again, I would emphasise what I call "systems approach" where I believe the farmer should be involved to the extent that is possible for him, given his technical background or lack thereof, for him to be involved in defining the problems and defining what sorts of things he would like to see done so that the research worker does not lose sight of what the purpose of the work is.

Siriwat: I am in livestock extension and I would say that what the speaker has described, we have done through another line. First we gave farmers improved breeds, like Brahman bulls. For the forage, we get the forage seed to them from the government and arrange for its dissemination. Vaccines are given for free by a volunteer in the village. For the rice grower we have demonstrations by the District Officer down to the village level. For the livestock farmer we just had some urea–molasses blocks distributed to the farmers as a demonstration, because we cannot give the blocks to all. We always find that women have a big role in helping us so, as the speaker said, I think this is an area we should concentrate on. Because they provide labour to raise chickens, pigs or even dairy animals, they can do more than males. When we talk about new techniques, we find it is the women we can teach more (I don't know why!).

David Little: The availability of poultry vaccines at the village level appears to be a constraint almost everywhere—despite demonstrations that you can vaccinate numbers of poultry. Are there any successful stories of sustained vaccine use by smallholder poultry producers in Asia?

Carroll: In Bangladesh, we have had a lot of success in the last 10 years with village animal health workers and poultry development where mostly landless women are involved. We have broken the whole poultry production cycle into each component part, so one woman will have a hatching system hatching may be 300 eggs at a time. She sells the day-old chicks on to a chick raiser, she will raise the chick to six weeks and will pass it on to a pullet raiser, and then on to a layer

farmer, usually women. And involved in that process, and what has really revolutionised the whole system and enabled it to happen, is the availability of Newcastle disease vaccines in the villages administered by selected village woman who had been given a small vaccine kit and trained to give the vaccines.

Mukherjee: Chairman, unfortunately my colleague Professor Latif is not here, but in Malaysia in collaboration with Australia we have developed a vaccine which is administered through the feed and this feed vaccine actually takes into account modified combinations of strains of Newcastle disease vaccine. It has been demonstrated that the immunity can be long term and this is now being investigated in many trials in Asian and African countries.

Carroll: I am aware of that vaccine, but I think it is still fairly costly for the village level which is maybe why it has not been utilised very much. Also the feed production is very piecemeal and localised, the mixing becomes a problem.

Leng: I wanted to bring up the whole concept of the effects of increasing environmental concern on the future of animal production because it has not been raised.

I have been in Cuba recently. Cuba has a system where plenty of fossil fuel used to be used and there was acceptance of high technology, rations, grain use, concentrate feeding etc which, on the removal of the Russian subsidies on fossil fuel has created a bigger problem than previously. Without all the inputs, agricultural production has fallen to the extent that people are now hungry in a country that previously had standards of living equal to many of the developed countries.

Carroll: This can be demonstrated by the effects on milk yields where high input requirements cause small farmers to go out of business. I think that argument also applies to crop yields if I am not wrong as the high yielding varieties of wheat, maize and rice depend very much on high fertiliser application and high water application. If you remove those the actual yield is less than the local strains or the local varieties that were replaced. I guess we are really caught in the nexus: there are so many people to feed in the world there is no going back. If we cannot provide the necessary inputs to maintain the production levels then we really have a problem that we are likely to face in the near future.

# ICLARM's approach to the integration of aquaculture into sustainable farming systems

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## Summary

Aquaculture in developing countries can improve the sustainability of small-scale farms provided that it is fully integrated with other enterprises and household activities so as to allow farm families and communities to manage their natural resources effectively. This requires the consideration of pond management and fish husbandry as means to a variety of ends (water storage, soil conservation and fertility, integrated pest management etc), not just production of fish. This approach to integrated resources management (IRM) is described with reference to the Inland Aquatic Resources Systems Programme of ICLARM. The benefits of this approach are illustrated with examples from South-East Asia and Africa. The research methods and remaining research challenges are also described.

## Introduction

Recycling the biological resources, wastes and by-products of a farm can husband natural resources and improve productivity and incomes. It is well known that soil fertility is improved when organic matter is returned to the soil. Farmers estimate that compost materials can replace basal applications of the elements nitrogen, phosphorous and potassium to reduce fertiliser costs by up to 50% (Lightfoot et al 1994). Recycling is a bigger part of the farm economy than has often been appreciated because it is difficult to measure. Indeed, when recycling flows are given cash values, the gross incomes of farmers increase dramatically, e.g. the value of all recycled materials can be up to 40% of gross farm income. High value flows are exemplified by the use of rice grain to feed chickens, or snails to feed chickens, ducks and fish. High volume but lower value flows are exemplified by those for rice straw, which is utilised both as livestock feed and compost material, and Napier grass which is used as feed for cows, carabaos and goats. The carabaos, like most livestock, contribute to recycling by eating grass and crop residues and producing manure (organic fertiliser) for the crops. Moreover, the carabao is used as a draft animal and also produces milk and meat. Ducks produce eggs, meat and droppings. And fish convert crop, livestock and household wastes into high quality protein and nutrient rich pond mud. Pond mud is so rich that it can replace fertiliser completely in small vegetable gardens.

Taken together, the direct and indirect effects of recycling can have significant impacts on the ecological sustainability of the entire farming system. Indirect effects include the integration of new enterprises that promote recycling and the rehabilitation of natural resources that either result from recycling or are necessary for enterprise integration. This paper illustrates ICLARM's experience with the introduction of aquaculture into smallholder farming systems and its role in catalysing new resource flows and recycling of farm resources in these systems.

# **The role of aquaculture in mixed farming systems**

Integrated farming systems, with aquaculture as a major or minor component of crop- and livestock-based farms, differ greatly from extensive or intensive fish farms that are stand-alone enterprises. Stand-alone fish farms can be risky ventures, especially for resource-poor farmers in developing countries, because of their environmental effects, e.g. pollution, and economic factors such as the price volatility of some aquatic produce, especially exports. Such ventures have resulted in environmental and financial disasters in Africa and Asia (Cross 1991; McClellan 1991; Polk 1991). Despite some individual success stories, intensive aquaculture has done little to reduce poverty and malnutrition overall.

Integrated farming systems that include semi-intensive aquaculture can be less risky because, managed efficiently, they benefit from synergisms among enterprises, diversity in produce and their environmental soundness. On this basis, integrated systems were suggested as the model for the development of aquaculture by small-scale farmers in developing countries. The various combinations of fish with livestock and crops, designed by scientists, often performed impressively on research stations (e.g. Hopkins and Cruz 1982; Edwards 1983), but on-farm performance was mixed (McClellan 1991). Moreover, the success of rice–fish (small fish in rice floodwaters), pig–, chicken– or duck–fish systems was usually evaluated solely on the production and profitability of fish or other aquatic produce. Making such systems work towards only these objectives can escalate costs beyond the means of small-scale farmers.

Small-scale farmers are averse to the investment risks in new ventures like aquaculture, preferring to see risks spread among benefits to other farm enterprises and household needs, such as secure water supplies. For aquaculture to be integrated at this level of complexity, farmers must participate in system design. The narrow view that small-scale, relatively intensive fish production should be the sole or primary goal of integrated agriculture–aquaculture systems needs revision.

## **Sustaining small-scale mixed farming systems**

Farmers possess large stocks of indigenous knowledge that include methods of adapting and generating technologies (Richards 1985; Lightfoot 1987; Warren 1991). Over the last few years, much progress has been made in formalising the participation of farmers in agricultural research (Chambers et al 1989; Haverkort et al 1991; Hiemstra et al 1992). ICLARM's view is that the horizon for research in aquaculture must go beyond fish production and cash income to evaluating the social, cultural and ecological services that pond water and pond biota, including farmed fish, can provide in an integrated farm that has aquaculture even as a minor enterprise. In some circumstances, improved aquaculture and water management may serve as the key to the sustainability of the entire farm (Lightfoot 1990; Lightfoot and Pullin 1991).

Sustainability is only likely to be approached when farmers manage their natural resources ecologically (Altieri 1989). Degradation of resources (soil, water, diversity and health of terrestrial and aquatic plants, animals and their products) will constrain the options for the evolution of integrated agriculture with aquaculture systems.

To counteract this, a broad view of integrated farming, encompassing fully integrated management of all the natural resources available to farm households is

recommended. ICLARM scientists have proposed the term Integrated Resources Management (IRM) to describe the approach (Lightfoot et al 1993a).

## **The integrated resources management approach**

The IRM approach integrates the management of new enterprises, particularly aquaculture, with those of the existing farming system and with their respective natural resource systems so that opportunities for rehabilitation and synergism can be exploited. The utilisation of the economic, social, nutritional and ecological services offered by managed water resources and fish is seen as a basis for sustainable farming systems. Thus, households are encouraged to see farm enterprises (particularly aquaculture) as mechanisms to improve natural resources management and overall farm system performance. The approach involves interdisciplinary research in close partnership with the targeted resource-poor farmers. Indeed, the use of indigenous categories of natural resource systems as entry points for research builds a common foundation for farmers and researchers.

Natural resources management and rehabilitation, and farmer-participatory skill-building, have shaped ICLARM's research agenda in an attempt to find procedures that will be used by farmers to help them make their own decisions and conduct their own experiments on how to integrate aquaculture and use their resources in a more sustainable way (Lightfoot et al 1993b). The Participatory Research Appraisal method that has been developed uses household groups to identify and map indigenous categories of natural resource systems. Village transects are used to summarise this information in a format easily appreciated by community members, extensionists and research workers alike. These diagrams serve as foci for the additional detailed development of the bioresources within individual farms. Detailed descriptions of this method have been published in ILEIA Newsletter (Lightfoot and Tuan 1990; Of ori et al 1993; Lightfoot et al 1994)

The bioresource flow model (or BRFM, shown in Figure 1) is a picture of the natural resource types, drawn as topographical cross-sections of land and water resources. The enterprises conducted on them are drawn as icons and the farm generated by-products and wastes that flow from one enterprise to another are drawn as arrows. Manure to crops, rice bran to pigs, and tree leaves to goats are typical examples of bioresource flows. Recycling does not include product (e.g. grain) flows to market or to household consumption except where household wastes, i.e. kitchen waste, cooking ash and night soil are recycled. Similarly, external inputs to fields like inorganic fertiliser are not included because they do not depict recycling. Bioresource flows can be expressed in several "currencies", like biomass, nitrogen, energy and cash. We have found biomass to be the most useful when discussing recycling with farmers.

The strength of the models is that they help people learn about recycling. They do, however, have weaknesses. During discussions, farmers often ask how they should split up their meagre supplies of manure among enterprises. BRFM cannot provide a complete answer. Farmers can be helped by visiting other farmers' plots or experiment station plots. It is, however, very difficult to generate the conversion coefficients for many wastes, particularly manures and composts, because they are so variable. This difficulty is increased by problems in trying to evaluate bioresources that do not have a market value. Simply using costs of labour involved in making the transfers, or using equivalent costs of chemical fertilisers, underestimates the true value of these materials.

Projections of the management strategies before and after integration (Figures 1 and 2) convey clear pictures of the impact of new technology adoption and integration. They help farmers and others appreciate the importance of shifting the boundaries and focus from the individual enterprise to the entire natural resource system used. The projections also help people appreciate the benefits to be realised from managing resources in a complementary and integrated manner that makes efficient use of available biological materials. ICLARM projects in countries in Africa and Asia have employed these techniques (ICLARM 1992) and the impact of this work on farm households, farm ecology and the environment is illustrated here through examples from Ghana (and see figures 1a and 1b), Malawi and the Philippines (and see figure 2).

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**Figure 1.** *Example, from a farm in Ghana, of resource assessments and resource flows before (Figure 1a) and after (Figure 1b) a participatory farm analysis to integrate resource management.*

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**Figure 2.** *Illustration of bioresource flow between natural resources before and after integration (example from the Philippines).*

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## The impact of the approach

### Ghana

Over the last two years, in co-operation with the Institute of Aquatic Biology and a local NGO (the Ghana Rural Reconstruction Movement), a group of farmers in the Mampong Valley, Eastern Region, Ghana, drew bioresource flow models of future integrated farming systems. Their plans to rehabilitate water resources for dry season vegetable gardening and aquaculture are now being realised (Otori et al 1993; Prein et al 1995).

Bioeconomic models were constructed to assess the potential impact of integration on the nutrition of households. The model used a rural household of five persons to compute the annual demand for the main nutritional components. The annual nutritional supply to such a household was calculated for a holding size of one hectare of which 60% was cultivated and the remainder under fallow. Crop yields were based on data from the Ministry of Agriculture. Nutritional inputs to the diet from staples, vegetables and condiments, freshwater and marine fish and meat were considered using data from various sources (Ruddle 1995). Integration added the outputs of a 100 m<sup>2</sup> fish pond and a 400 m<sup>2</sup> vegetable plot. The models suggest that integration can improve both household nutrition and cash income (Ruddle and Prein 1994). The most significant nutritional impact from integration was the boost in protein intake from around 60% of recommended levels to over 120% and increases in the availability of vitamin A (66%) and vitamin C from the additional vegetables.

### Malawi

In Malawi there were both tangible products and organisational benefits from the approach which resulted in the stabilisation of household incomes. Initial results

from five farms in 1992, part of a group of some 30 farms new to integrated farming, indicate that adoption has had significant and diverse impacts on farm management and the performance of farming systems (Lightfoot and Noble 1992). Ponds served as a focal point for direct or indirect links between resource systems. Households used the ponds as water catchment for domestic use and watering livestock. Ponds placed adjacent to vegetable gardens provide water for irrigating these gardens and earnings increased from US\$ 82 to US\$ 112 a year. Ponds were utilised as processing units for converting low quality crop residues such as maize bran and green leaf waste into fertile mud for transfer to gardens. This reduced fertiliser use and brought marginal land into productive use. The ponds resulted in a ready supply of fish for household consumption so that families rarely had to buy fish. The average value of a single fish harvest was US\$ 22 and US\$ 45 for two harvests. Conversion to the use of ponds provided food and income (the average income from integrated rice–fish farming was US\$ 76/year). Some households were able to grow rice for the first time and rice–fish pond integration provided two crops of rice per year. The average annual income after integration was US\$ 235. The contribution from rice and fish pond alone to gross farm incomes varied from 10 to 62% in 1992, a year that saw a nationwide drought and a currency devaluation of 20%. The fact that these households managed to stabilise if not slightly increase food and cash in a year of drought and devaluation is a remarkable feat in itself.

## **The Philippines**

To assess the impact of changes in natural resource management, data were collected via direct monitoring and from recall from seven households in Niugan, Cavite Province, the Philippines, in co-operation with the International Institute of Rural Reconstruction. These data were used to calculate four simple indicators of sustainability for each farm: economic efficiency (net income in US\$), resource system capacity (biomass output in tonnes per ha), species diversity (number of cultured and utilised species) and bioresource recycling (number of bioresource flows). For example, on analysis a farm was characterised as having six enterprises and two resource flows. Upon integration these increased to 11 enterprises and six flows. The newly introduced fish pond opened opportunities for the culture of fish and water spinach using on-farm inputs. Existing by-products were subsequently used to a greater extent. These low-value flows led to the production of high-value products. Diversification and integration brought about an increase in net income from US\$ 350 to US\$ 750 and biomass production from 7 to 8 t/ha.

By plotting the indicators graphically in a time series, new information was revealed on the direction of evolution of the farming systems over time. The positive or negative impacts of management changes and the adoption of technologies can be gauged in relation to performance of the system. The individual indicators fluctuated within years due to seasonal differences and climatic change. The general trends, however, showed a gradual and steady improvement in overall farm performance with the advent and integration of aquaculture. Greater water availability allows for its improved use, not only for fish and aquatic plants but also for rice and vegetables. Enterprises and natural resource systems thus support each other through improved management and use of the water and bioresources leading to a simultaneous increase in all indicators. To compare the situation "before" and "after" integration, data from individual time points from the time series graphs were taken and plotted in kite diagrams (Figure

3). These provide at-a-glance information on changes in performance with time: the larger the kite the better the performance.

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**Figure 3.** *Farming systems performance indicator kites before and after integration, using data from the Philippines.*

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## Future requirements

These initial results suggest that the IRM approach is promising. Small but growing numbers of farmers are beginning to adopt IRM resulting in the rehabilitation of aquatic resource systems to the benefit of many enterprises. Clearly, some farming systems can be transformed rapidly—The monitoring of sustainability indicators shows this—but are these indicators the right ones or the only ones? The counts of flows and species should be designed to take account of quantity as well. Importantly, more direct determinants of the quality of natural resource systems need to be found. For instance, farmers in Vietnam have reported that fish in rice fields enable them to reduce fertiliser inputs by 28% (Lightfoot and Tuan 1990). Similarly, farmers in the Philippines report that fish saved US\$ 12 per hectare on herbicides and US\$ 13 per hectare on pesticides (Fermin 1992). However, whereas cash substitutions for inorganic fertiliser and chemical sprays can be calculated, values for natural resource system rehabilitation, species diversity and bioresource flows are much harder to determine. Further, indicators for equity, particularly gender equity, and ecosystem attributes such as resilience and maturity are also needed. The use of ecological modelling tools like ECOPATH (Christensen and Pauly 1992; Dalsgaard et al 1995) may contribute to the development of these more sophisticated descriptors of farming systems.

Given the benefits that can be achieved by recycling, far fewer farmers adopt this approach than could. Farmers give a wide range of reasons why they or their neighbours do not recycle: cultural taboos, it is not regarded as modern or progressive farming, competition between domestic uses for manure, such as for fertiliser or fuel, lack of access and tenure preventing nutrients from being brought into the recycling option, e.g. not being able to grow fodder trees or graze animals on the "commons", are typical examples. However, perhaps the most common reason given for not recycling materials like manure is that buying inputs is quicker than recycling, which is time-consuming and labour demanding. Simply, the returns are either too uncertain or too modest.

Enterprises that can turn low quality plant residues and by-products into feeds and fertilisers for other enterprises are vital. Fertilisers will still be needed, but to supplement organic materials rather than replace them. In some cases this will not be enough to provide satisfactory returns to the high labour inputs required. As long as chemical fertiliser is cheap or subsidised and organically grown food is not subsidised, it makes little economic sense to recycle. Perhaps the most important challenge facing those concerned with the ecological sustainability of agriculture is the development of supportive agricultural policies. Policy instruments that promote and guide the evolution of IRM systems need to be formulated. Approaches that assist the resource-poor, particularly women, are in turn bound to equity issues both within a household and in the community at large. Successful exploitation of underutilised natural resource systems are bound to attract more

users than they can carry. Avoiding these problems in integrated farming will require the whole-hearted participation of the community in IRM.

## Acknowledgements

This report (ICLARM Contribution No. 1158) is a synthesis of recent research and was made possible by the contributions of ICLARM staff and their partners in national institutions. Readers are referred to the papers by Lightfoot et al (1993a, 1993b, 1994) on which this presentation is based and which list collaborating partners.

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# The development of the CGIAR's System-wide Livestock Initiative

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I thought that this might present an opportunity in the agenda to say something about the system-wide livestock initiative. I think it is very relevant to this session on international approaches to livestock research because, as Dr Fitzhugh mentioned yesterday, the System-wide Livestock Initiative is part of the system-wide livestock programme which encompasses all the livestock activities of the CGIAR system.

Secondly, it is an example of an important new development within the CGIAR system—that of developing ecoregional and system-wide initiatives. It is important also because we are expecting an IRRI-led consortium to be put together to put forward a proposal for South-East Asia for consideration in the next few months. This will provide some preamble for the discussions that we are going to hold on this consortium, and in fact the System-wide Livestock Initiative has been taking advantage of various meetings that have been held in the ILRI consultation series so that we don't have to arrange separate meetings for this initiative. It has been an excellent opportunity to meet the NARS from four major CG regions. I will give you an overview of the document<sup>1</sup> that was presented to the Technical Advisory Committee in Lima, Peru, in March 1995. This was our proposal for the system-wide livestock initiative to go ahead and we are initially concentrating on feed resources research, production and utilisation. This document was based on previous CGIAR, TAC and ILRI documentation. In fact, the justification for the initiative you are all familiar with I am sure, came from FAO and World Bank statistics. Very simply, the rationale is that human population increases are going to put tremendous pressures on agriculture and the natural resource base. The human population increases, and the urbanisation and diet changes are all going to increase the demand for food and food of animal origin and this is going to fuel an increase in animal production, intensification and an expansion of livestock numbers. All this means that they are going to require a greater amount of energy and protein to support these trends. The initiative, which may be funded initially to the amount of US\$ 4 million, is thus seeking proposals for research from consortia of institutes with CGIAR centre members addressing improvement in livestock feeds from the major ecoregions of developing countries.

1. Programme Plan and Funding Request for the System-wide Livestock Initiative, Feed Resources Research Production and Utilisation, ILRI. April 1995. 25 pp.

# Asian Development Bank

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The Asian Development Bank was created by a number of countries in 1966 and commenced operation in 1967. There are at present some 56 member countries, of which some 16 are non-regional. The Bank's responsibilities range from new members like Uzbekistan and some of the other countries which were previously under the Soviet regime which have recently joined the Bank in the far west, to Sri Lanka in the south-west and right over to the Marshall Islands and Cook Islands and other Pacific countries in the east, and as far north as Mongolia and the People's Republic of China. So we have a very broad coverage—around half of the world's population.

The Bank has its headquarters in Manila. It has some 650 professional staff and around 1200 support staff. Rapid changes are taking place as mandated to us by our Board of Directors and we expect to have at least 100 professional women staff by the end of 1996. The Bank is governed by a governing body made up of representatives of the member countries. We also have a Board of Directors actually located in the Bank. The Board is made up of people sent from these ministries and some other institutions. The Bank has a president and three vice presidents, and its operational departments are roughly divided into East and West groupings; there is also a finance and administrative grouping of departments.

The Bank's operations cover a very wide range of activities from agriculture through ports and shipping, power generation, airports, roads, many social issues, poverty alleviation, special women's projects, water supply and sanitation etc. There are different types of loans. The major portion is what is called the Ordinary Capital Resources (OCR). These are the funds used for our "so called" hard loans. These loans carry a variable interest rate reflecting the cost of the Bank's borrowed funds from the international capital markets. Loans from OCR, which account for more than two-thirds of cumulative bank lending, are generally made to countries in the region that are further up in the development ladder.

Some of the poorer countries, which includes most of the South Pacific developing member countries, Bangladesh, Nepal, Bhutan, Sri Lanka and others, qualify for our so-called soft loans or the Asian Development Fund loans which are lent at virtually no interest rate. We have a 1% service charge per annum, but no other interest rate.

The loans have a grace period, in the case of the soft loans or ADF, the grace period is 10 years and the repayment period 30 years. So you are looking at some 40 years before the loans are fully repaid. So ADF loans are really a very cheap source of money.

One of the Bank's strengths, as is frequently pointed out, as opposed to normal commercial sources of funds, is our technical assistance programme which provides backup or underpinning for project activities. There are three types of technical assistance support which ADB gives. We have Advisory TAs or so called ADTAs which are not linked to projects and are given for a variety of reasons, e.g. for institutional strengthening to develop the ability of the Ministry of Finance to

manage the countries' economies better, or it may be to a livestock department to reorganise itself along more efficient lines.

We also have what we call our project preparation TAs. The project preparation TAs or PPTAs, are directly linked to the preparation of a feasibility study which the Bank may then consider financing. The bulk of our TAs are PPTAs. We also have what we call RETAs or Regional TAs and this would be more applicable to the sorts of activities that ILRI and CGIAR organisations are involved in. IRRI and ICLARM are the only two who are locally represented and therefore in a position to get money from ADB. We do have very strict rules on lending within our member countries.

The sources of funds for organisations such as IRRI and ICLARM would be sometimes under an ADTA if they have been selected to undertake an advisory or institutional building TA. But RETAs are the more likely source of funds.

The Bank, in the last few years, has increased its lending level to just over 5 billion dollars per annum. In the last year and a half our lending rate has dropped, and last year our lending rate fell to 3.7 billion dollars. The reasons for this decline have been several. One is, I am sure you are all aware, the demands being made on all multinational organisations to improve the quality of the projects that are being prepared. And within that quality requirement is more attention to the sociological issues, and more attention to general project quality to ensure that the best impact is made on a dollar for dollar basis. This has meant the introduction of a lot of additional hurdles in order to go from feasibility study to a project that's actually being implemented, and a slow down in lending.

The Bank has provided quite a lot of support to livestock development in Asia over the last 20 years. In fact, when I joined the Bank we had a division in the Department of Agriculture called Division of Fisheries and Livestock and during that phase there were a number of projects on livestock prepared in the Pacific, Korea, Bangladesh, Nepal, Bhutan and Sri Lanka.

The Bank has provided several hundred million dollars of support to the livestock sector. Attitudes to supporting the sector changed when project completion reviews rated completed projects poorly, mostly due to lack of proper data to measure the impact of the projects. I think this is something that the International Livestock Research Institute (ILRI) needs to consider: the need for proper monitoring and evaluation which can be very difficult when dealing with the livestock sector. You are dealing with a sector which has, in some cases, not been rated very highly in people's minds. In many cultures, livestock raising is done by the lowest members of the society so within the hierarchy, any institutional arrangements dealing with livestock in the past have not had a great deal of priority. The post-evaluation the Bank carries out on all projects, and the project completion reviews, have come back with very poor internal economic rates of return and financial rates of return for previous livestock projects. These were often quite different from the original estimates made during the preparation of the projects. Consequently, Bank management started to look with very jaundiced eyes at livestock and the livestock sector, thinking that it was not bankable. That the investment were not worth the outcome that we were achieving. But I think this was misplaced and there are lots of indications to show that what was really the problem, was the lack of adequate baseline data. The information that is available in many countries is frankly of very doubtful use, much based on overestimates which have then been given a guesstimate growth figure over a number of years.

So with inadequate databases, and then the lack of effective monitoring and evaluation during the implementation of the project, and the failure to develop proper criteria for evaluating the project, at the end of the day the people responsible for evaluating the project came in and evaluated it as best they could, often using very limited financial resources. They found that most parameters they could measure did not seem to amount to very much. So livestock was given a very bad rating.

But time is showing that our projects in livestock in fact have had a very big impact, and I use the example of Nepal. The first livestock project was rated very poorly in the Bank. But now Nepal has suddenly gone into a milk surplus situation as a direct result of the first project. There were things there that the post-evaluation mission did not evaluate. But the net result was that rather than having a poor impact it in fact had a major one—it just had a longer time span or delay before the impact was measurable. I would like to underline this for ILRI as being a very important aspect: to develop the right criteria for measurement of the progress and impact of livestock projects.

The major thrust of our projects obviously has been on animal health. That has always been a major requirement when we first go into countries to improve their livestock production. This has meant setting up diagnostic systems, central disease diagnostic laboratories, regional diagnostic laboratories, a proper veterinary field service and then supplying them with the necessary vaccines and medicines. The production of vaccines has also been included in the project. Animal breeding is another area in which the Bank has made a major thrust with a lot of activities and development in artificial insemination and the introduction of exotic breeds and cross breeding.

Nutrition, I believe we overlooked earlier on. But nutritional aspects are now taking a much more important role in project development. Extension is another major issue which we are putting a lot of effort into.

We have built training institutions. So we are involved in university development in specialised livestock training institutes which have been built in a number of places. Production and processing aspects, improved animal husbandry, all those aspects on the farmer's side are given very high priority, but we are now switching some of the emphasis to the need to look at the marketing side first. The farmer is not helped if on producing something he can't sell it at a good price.

Marketing is extremely important and this includes processing and improving the value of product. The Bank has been responsible for a number of milk processing facilities in quite a few countries, e.g. milk recombining and packaging, and production of various other dairy products (yoghurt, ice-cream etc) have been included in some projects. Meat processing is another area that has been supported; the proper hygienic slaughter of cattle and distribution of meat is another area that requires support in many of our countries in Asia. Hide processing is an area that needs further development, and there is a lot of potential for improved economic gains from value adding to hides which are currently not being followed up in some countries. Another aspect that I would like to stress is the participatory approach or the need to involve the beneficiaries and other stake holders in the development of interventions or of projects.

Technological interventions are not enough. They never were but we thought they were earlier on; the most important aspect is whether or not those technological interventions are appropriate and whether people are prepared to make the effort to

implement them and whether they want the output. So we must involve people in the process from day one, right from the very beginning. These people should include the direct beneficiaries and other expected beneficiaries in addition to the other stake holders, i.e. people who are responsible for providing the support and infrastructure and for the money.

## General discussion on day II

Fitzhugh: I think it was very useful to end the morning's discussions with talking about the end user, where the Asian Development Bank might use the results coming out of research activities at different levels. I want to come back to your point about the need for better indicators, not only of the success of the projects but also as they relate to the needs of the people who are involved, because in the previous presentation that Thelma Paris made, she highlighted risk aversion on the part of farmers as a constraint to adoption. This may be a very difficult area; the Asian Development Bank is also concerned about risk aversion, but probably at a much different level from that which the smallholder is going to be concerned about it. The Grameen Bank is also concerned about risk aversion but they have come up with different modalities. As you formulate projects that you anticipate having an effect really at the macro level, how do you see or how do you evaluate risk aversion at the farmers' level and how will that really work to the success of the levels of projects which you are going into?

Carroll: Yes the question of risk aversion is different for us. They [the farmers] know that when people come along with a totally new approach they have absolutely no guarantee that they might not be starving next year. So I think we have to be very thoughtful and very careful in the way we carry out the interventions to ensure that the farmers are not left in situations where they can no longer support their livelihood.

And this means, I think, more dependence on the private sector in the future than perhaps we have done in the past, because the public sector has shown itself to be wanting in many countries. This is for various reasons—probably it's not so much blame on them it's only that bureaucracies are not set up to do certain things. They are certainly not set up to do production activities effectively and it's probably much more efficient to have private sector delivery of supportive mechanisms where that is possible. Those have to be developed and that's where our seed role, if you like, becomes important. But in terms of farmers' risk aversion, I think if you involve them in the process from the very beginning you get ownership and commitment as well so they have more confidence in what is being provided to them. But you must also ensure, and this is when it becomes very complex, that you've got all the difficulties such as the macro-policy issues factored in. How many of our projects don't work because the macro-economic policies are absolutely against what it is we are trying to do? A lot of subsidies of agricultural products are totally against the improvements that we are trying to bring about, so you have to make sure they are removed before you start pushing the farmer to change his view. You have to make sure that the marketing outlets are there. It is very wrong, in my view, to entice a smallholder farmer to change his way of working and his way of production to produce a product that he then has trouble selling. It is not an easy issue and a lot of people just don't comprehend the complexity of livestock, which I think is more complex than any other form of agricultural enterprise.

Fitzhugh: We talked about a participatory approach and that's important in project design, but one of the most effective ways to transfer technology is demonstration. Where this has worked out well, there was support and even a safety net provided to those who ran out on a limb to try and utilise new technologies. It amazes me that in this Asian farming system network where *Leucaena* and *Gliricidia* were put out on farms, the farmers did not chose to use the leaves because of the experience they had had with abortions in non-ruminants. One of the things to do would have been to go into those villages and actually work with the villagers to demonstrate and say, well, if you do have abortions from the trail feeding we will stand behind and we will protect you from the risk.

Carroll: I couldn't agree more. When you involve the stake holders you still have to demonstrate the advantage of the technology and that should be on-farm rather than on an experimental farm. Just as all farmers know, the experimental farms are interesting and it is a nice day out but it has got very little to do with reality. It is also important to tailor, for example the seed packaging and fertiliser application for different areas. Location-specific packages are required.

It takes time to develop these but once they are demonstrated (we had trials in farmers' fields—we negotiated with farmers to lend fields on which trial crops could be grown and other farmers from the neighbourhood come and see), it was very impressive how quickly farmers adapted to this technological packages once they realised the benefits.

In Bhutan, for example, once the farmers could see the advantage of growing leguminous pasture and the huge increase in milk production that was brought about semi-agriculture was taken out and converted to permanent pasture with livestock, purely because the farmers get more money from more milk from their cattle. This was preferable to the very meagre crops that they were getting on these particularly steep slopes which was causing soil erosion.

The other important thing in risk aversion, is for a government or a project in its initial stages to even have a buy back scheme. For example in Bhutan and Nepal for seed production and to develop national seed self-reliance, the government agreed to buy back pasture seed from farmers at a guaranteed price. This has taken off to the extent that in Bhutan the government has been able to back out of the system, largely, as farmers are selling more to one another than going through the government system. We are trying to introduce the same process in Nepal.

Anders: Given that the emphasis seems to be on farmers' participation and that sort of work and the description we had earlier of the system initiatives, I would be interested in knowing how ILRI sees the mixture of activities in those projects between research and development, and within the research agenda itself the spectrum of say strategic research versus adaptive research. And how they see these all fitting together in a project proposal.

Fitzhugh: We have given a lot of thought to it. Derrick Thomas's presentation on these initiatives, because of it being prepared probably for a different audience, was focusing very much on the role of the CGIAR centres. One of the particular advantages of the consortia that are being developed to focus on problems at the regional level, is that these are consortia made up primarily of national research institutes. And the national research institutes, if they are working effectively, will also be linked to the extension services. We can talk about the pipeline for international research being 10 or 15 years, but if we are going to maintain support for research then we must move some technologies to farms at a much more rapid rate than that. The national scientists have the advantage to do that as they are closest to the farmers. So we will give highest marks to those proposals coming from consortia that have built into them the range of strategic research that may be undertaken with a long-term view but also a linkage to adaptive research so there will be much more immediate demonstration at the farmer's level to move the research through. There are technologies that are ready to be adapted and you can support the national institutes to do that. Then there is a need to look ahead to increased population pressure, differences in cropping systems, changes in market demands in the future etc, and so if you build in the type of research that will address these future needs the research and adoption process will become a continuum.

Carroll: I suspect that ILRI could play a very important role in networking and interacting with national research institutes to help get them to focus on the right issues and encourage them to improve their research activities.

Leng: We have a huge problem between national research institutes and farming because the extension services are very poorly developed in most of Asia. This leaves the big problem that we have in identifying who we work with if we are international institutes. Somehow extension services have to become extension services plus demonstration services. An extension service in general does not demonstrate anything it generally talks about it. One big reason we can't get technology down to the farmers is that there is no mechanism for doing it.

Carroll: It again relies on getting the motivation and commitment of the extension staff. In Nepal we've moved to a farmer group concept (which I know has been tried previously but this has a different set of criteria for establishment) which has worked very well. Suddenly we have a situation where the farmers are really pushing the extension worker for information and for inputs, and this has had a big impact.

David Little: Dealing with agriculture and promoting improved fish culture for small-scale farmers has specific problems. It is very difficult to do effective demonstration in the way of a field of improved crop. You can't see into a fish pond and say how a fish is growing faster, for instance. Generally fisheries departments may have responsibility for extension but even compared to the general agricultural livestock services the number of extension offices is extremely small perhaps servicing several hundred thousand farmers. So we have been really

forced to think first of all what we are trying to extend to farmers. We actually focused attention on the two pieces of information out of a possible 10 which gave the biggest bang for the buck, and this prioritisation of the type of research you are doing both on-station and with the farmers, with the view of who your eventual clients are, I think is very important.

Anders: I would like to follow on a little further with the idea that the objective is to have impact rather fast. In some areas it is sometimes easier to work and move technologies through NGOs. I would venture to guess there are a variety of opinions here and I would be interested in knowing first of all if ILRI sees a role for NGOs in these projects. What are some of the feelings that people from various countries have about involving NGOs in this type of work?

Carroll: That's a very good question. I can name a couple of countries where literally thousands of NGOs have sprung up in the last couple of years and then you have to sort out the wheat from the chaff. There are some very good NGOs. Bangladesh has some excellent ones, very effective ones, with several thousand staff working in the field and they really make a big impact. A good NGO can be extremely useful because there are working at the grassroots and have knowledge and connections which other institutions don't have and even governments often don't have.

Steane: I think this link between the national agricultural research and the extension is a key area but there is a problem which is more to do with social status than anything else. Extensionists are usually thought less of than scientists. That is putting it bluntly but is characteristic of the attitudes you meet so frequently. I think that is a real dilemma and I don't see any easy solution, however we try to get the messages across.

I think the other side of the same coin which has made life more difficult is this myth which is perpetuated by some of the major institutions which is that extension should be totally paid for economically. No developed country in the world has yet achieved that position. The nearest is New Zealand; the nearest in Europe is a 30–40% return on your costs and so if the institutions which loan and give money, the donors, pretend that they can achieve something which is not achievable in the developed world, it is no wonder we have problems with extension.

Carroll: That's a point I will have to make some comment on because ADB has, as part of the privatisation process, been encouraging such development. I think it does work with certain types of extension activities in certain areas, not necessarily right across a country, but governments cannot afford the type of extension service that is really necessary. Therefore we have to find alternatives, and that's probably a mix, and in those areas that are isolated or where local farmers don't have enough money to pay for private sector support, then the government has to fill in that gap at least for the time being. But in some areas (there are many in Nepal and Bangladesh) there is sufficient money in the private sector and amongst the farmers to support artificial insemination and veterinary services on a private

basis. And there are many examples where in fact it's happening: in Nepal there are quite a few government vets and other extension workers who have moved into the private sector. They can earn more money working still on extension, still providing a lot of agricultural assistance to farmers, but are paid for it by the farmers groups.

Steane: I think you have to distinguish between veterinary services and extension.

Carroll: But you are talking about information dissemination and that's different, that's the right role of the government and that's what I keep maintaining. Governments should be setting up and concentrating on collection and dissemination of information, not being involved in production activities.

Doug Little: I appreciate this division David Steane has just made between extension, information and provision of services. When project formulation is working right down there with the farmers, and in collaboration with the national organisation, your extension job is half done when the farmer can see it and be a part of it. Frequently, the extension service is totally divorced from research and any other kind of service and that is a huge problem. The Indonesians are in the process of reformulating their entire service and they are making sure that research/extension linkages are established because they put them all together.

Regarding the problems of failure, some has been due to poor quality baseline data in the first place. I am wondering if with the sorts of proposals that (the ADB) are considering for funding now, are baseline and monitoring data being built in?

Carroll: It is very much considered as part of the project formulation but if we were to have a criterion that said you can't move on until you've got perfect baseline data, we would probably never do anything. There comes a point when if you know you are starting from a very poor database you just have to do the best you can, and try and turn to other more quantitative criteria for the measurement.

Qureshi: Coming back to research related to this question, does ADB have funds for pre-investment in research? For example, participating in this consortium. Some of the results will be directly related to establishing some of the parameters that will be needed for project formulation.

Carroll: Currently, there is an agricultural research policy paper being prepared. I understand it will support CGIAR centres and IARCs for a specific project. But our mandate makes it very difficult to provide long-term funding. Our funding cycle is for five-year or three-year projects, and it's more for development than research.

So there is a responsibility, I believe, for international organisations, and that means getting the governments of various member countries to be willing to enable institutions to support such efforts. We have provided support, as I mentioned earlier, through specific projects. We have a lot of difficulty providing funds for core expenses and for operating expenses.

# Research priorities for improving animal agriculture by agro-ecological zone in Malaysia

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## Abstract

Malaysian agriculture is dominated by cultivation of perennial crops which succeed on land with adequate drainage. Most of the expansion of livestock, especially ruminant production, will therefore occur in integrated animal–tree–crops production systems. Commercial plantations, with the help of contract workers and plantation smallholders, will be the key elements for this change, although sustainable animal production may also be developed in the bris-soil areas near the coastal belts and uplands. This paper outlines the natural resources and current environmental problems in Malaysia that impede the successful and healthy development of animal production. It describes the government priority research areas in the following disciplines: production efficiency, breeds and breeding, reproductive physiology, nutrition and feed resources, product handling and food designs, pollution control, and companion, sport and recreation animals.

## Introduction

A significant rate of economic expansion is expected to change Malaysia to the category of a developed and industrialised country by the year 2020. The government is placing major emphasis on the expansion of the construction and manufacturing trades, and tourism sectors. This vigorous economic expansion in non-agricultural areas and export crop production provides two serious challenges for planners of agricultural development, and growth of supportive infrastructure. Firstly, it leads to further import of food items including livestock products and livestock. Secondly, exploitation of good agricultural land may lead to serious risk of soil impoverishment and erosion, water shortage during the dry season and ultimately negative climatic changes that will cause substantial food shortages before the year 2020.

To overcome these problems, new systems of agricultural development would be necessary with a view to integrating various components in the production and marketing systems. This kind of integrated operation is already practised in two sectors of animal agriculture, i.e. poultry and pigs. The economic **success of** these two sectors augers well for the establishment of similar integrated operations in the large and small ruminant sectors. However, to realise this objective, continuous research is needed to make the operations attractive to entrepreneurs, smallholders co-operatives, plantation sectors and managers of resettlement schemes.

## Natural resources

### Land

Malaysia has a land area of just over 33 million hectares. The percentage of land suitable for agriculture in Peninsular Malaysia, Sabah and Sarawak is given in

Table 1. Approximately 52% of the total area in Peninsular Malaysia, 85% in Sarawak and 69% in Sabah are unsuitable for agriculture (Amminuddin et al 1990).

**Table 1.** *Distribution of suitable and unsuitable land for agriculture.*

|                                               | Land area (ha x 10 <sup>6</sup> or %) |         |       |
|-----------------------------------------------|---------------------------------------|---------|-------|
|                                               | Peninsular Malaysia                   | Sarawak | Sabah |
| Total area                                    | 13.16                                 | 12.24   | 7.63  |
| Total area suitable for agriculture           | 6.19                                  | 1.8     | 12.31 |
| Total area unsuitable for agriculture         | 6.85                                  | 10.43   | 5.25  |
| As % of total area                            | 52                                    | 85      | 69    |
| Total upland areas unsuitable for agriculture | 5.61                                  | 8.57    | 4.49  |
| As % of total unsuitable area                 | 82                                    | 82      | 87    |
| Steep land (as % of total area)               | 3.6                                   | 70      | 22    |
| Slope (°)                                     | >20                                   | >33     | >25   |

Of the total area in Peninsular Malaysia, approximately 68% is forest and woodland; there are a million hectares of arable land, 3.3 million hectares of permanent crops and 0.4 million hectares of irrigated land. Mangrove swamps and coastal areas with bris-soil constitute the remaining area. Rubber, oil palm **and rice** are the major crops.

The pattern of land use in Peninsular and East Malaysia is the same. The arable land is already overcultivated but it still remains an important source of crop residues and agro-industrial by-products, which are used for feeding ruminants. In oil palm, rubber and coconut plantations (totalling 4.36 million hectares) a substantial part of the land can be used for cultivation of feed and teed supplements such as soybean, maize and legumes for animal feeding, besides utilising the native herbage for grazing of large or small ruminants. Research in this area has been developed by many institutions (Sivaraj et al 1993) but the resources in full are yet to be explored.

Rainfed ecosystems are also not properly explored although they have large concentrations of livestock. There is a great potential for livestock production in the upland areas as well as the bris-soil areas adjacent to the coasts, mainly the east coast of Peninsular Malaysia. In the hilly areas of East Malaysia and the central part of Peninsular Malaysia, many resource-poor farmers have inadequate knowledge of how to use natural resources without degrading the environment. Ruminant production in these areas and the research for a balance between a desirable environment and the agriculture/livestock production is the challenge for the future (Devendra 1994).

About 8% of the total land area is swamp land. The environmental degradation of this land has recently become a major concern. Fish, cockle and shrimp farmers in these areas may generate supplementary income by integrating chicken, waterfowl and even small ruminants in these areas.

**Topography and agroclimatological conditions**

From the mountain range in the middle of Peninsular Malaysia, many rivers flow to the east and west coasts. The east coast is exposed to riverine deposits and sandy

beach ridges, while the west coast is dominated by alluvial marine deposits. In the coastal depressions, about 8% of the land area is swamp land.

Sabah and Sarawak are generally mountainous and drained by an intricate system of rivers; almost 70% of the area is steep. The humid tropical climate of both Peninsular and East Malaysia (Sabah and Sarawak) is accompanied by heavy annual rainfall (2540 mm and above). Average daily temperature ranges from 21 to 32°C, and humidity is high with a mean value of about 85%. These agroclimatological conditions in Malaysia favour the cultivation of tree crops such as rubber, oil palm and coconut. The grazing of animals on the land in these tree crop cultivations offers great potential for animal industry, yet this potential is not yet properly explored.

## Animal production

During the last three decades, Malaysia has made significant progress in the development of the non-ruminant sectors (chickens, pigs and ducks). The country is self sufficient in poultry and pork although there is a huge import bill for animal feed ingredients for the maintenance of the two industries and for the purchase of parent stocks.

Imports of livestock, animal feeds and processed products in 1992 cost over RM 2000 million (US\$ 800 million). Export of some commodities in 1992 was only US\$ 469 million (Sarji 1994). To minimise this balance of payments, attention must be focused towards the development of vigorous ruminant production systems. Table 2 reveals the static or almost insignificant growth of ruminant production in Malaysia. Based on ex-farm values, the gross turnover of livestock primary and trading activities, exports and imports, is estimated at RM 4.8 billion. The secondary industrial activity is estimated to be more than RM 500 million annually.

| <b>Table 2.</b> <i>Per capita consumption of livestock products (1986–1994).</i> |       |       |       |
|----------------------------------------------------------------------------------|-------|-------|-------|
| Commodity                                                                        | 1986  | 1990  | 1994  |
| Beef (kg)                                                                        | 2.35  | 3.49  | 5.00  |
| Mutton (kg)                                                                      | 0.47  | 0.50  | 0.62  |
| Pork (kg)                                                                        | 9.70  | 10.30 | 9.70  |
| Poultry meat (kg)                                                                | 15.90 | 20.3  | 24.20 |
| Milk (litres)                                                                    | 40.50 | 38.5  | 49.40 |
| Eggs (no.)                                                                       | 241   | 280   | 295   |
| Human population size (millions)                                                 | >15   | <17   | <19   |

Non-ruminant production systems in Malaysia are classified into the following groups:

1. a) Industrialised system (large-scale production of chickens, ducks and pigs).  
b) Integrated with fish production.
2. Small-scale subsistence production systems
  - a) Non-integrated (chicken and ducks).
  - b) Integrated with paddy fields (ducks and chickens).

c) Integrated with fish production (pigs, ducks and chickens).

The advantages and disadvantages of the different production systems have been described (Mukherjee 1992). Comparative economic efficiency has always been in favour of the industrialised systems, but recently the trend is for increased consumption of native indigenous resources (especially village chicken) because of the taste, leanness and tender meat.

Ruminant production systems in Malaysia are mainly associated with:

- extensive systems of smallholders
- systems combined with arable cropping which include roadside, communal and arable grazing, tethering and cut-and-carry feeding
- systems integrated with tree cropping (Devendra 1989; Devendra 1993).

Table 3 indicates a strong association between increased per capita income of population and increased animal protein intake, while there is a decreasing trend for vegetable protein intake. This emphasises the need for strengthening animal production in Malaysia through efficient production systems management and low production costs.

**Table 3.** *GNP per capita and animal/vegetable protein intakes in Malaysia.*

| Year                                     | 1970 | 1980 | 1990 | 1993 |
|------------------------------------------|------|------|------|------|
| GNP per capita (RM)                      | 1128 | 3734 | 6203 | 8281 |
| Per capita livestock products intake (g) | 9.6  | 14.4 | 16.5 | 16.9 |
| Per capita fish products intake (g)      | 7.1  | 11.2 | 9.0  | 9.1  |
| Per capita vegetable products intake (g) | 33.2 | 33.1 | 28.5 | 28.2 |

Source: Adapted from Devendra ( 1994).

To meet the challenges of the future, the Department of Veterinary Services of the Government of Malaysia encourages increasing intensification of smallholder systems. It also encourages plantation management to integrate animals with perennial crops, downstream processing of animal products and feed (by-products of plantation industry), and quality assurance in the production of wholesome, safe and healthy livestock products.

## Feed resources

The feed industry is well developed with 38 feed mills producing a total of 3,185,000 t annually. Yet Malaysia has to depend heavily on imported feed ingredients such as maize, wheat, soybean meal, groundnut cake, fish and bone meals, skimmed milk powder, whole milk powder, dried whey powder, dicalcium phosphate, salt, sesame cake, corn gluten and lucerne pellets. Net import of feed grains showed a 20% increase from 0.87 million tonnes in 1986 to 1.04 t in 1989. About 90–95% of this amount is used for poultry and swine production.

Encouraging the use of local ingredients, (including palm oil mill by-products) in ruminant feeding systems would most likely enhance interest in formulating compound cattle feed. Palm kernel cake (PKC) could be the major ingredient in such a feed formulation. Current export of PKC to Europe is 800,000 t a year(Anon 1994).

Considerable amounts of forage are available from areas under permanent tree crops totalling 1.86 million hectares in rubber, 2.1 million hectares in oil palm, 2 million hectares in coconut and 1.85 million hectares in orchids. These green forages are currently either unutilised or underutilised. In addition, there are 261 grazing reserves of about 18,137 ha of which only 40% are planted with improved grasses. Bris-soil areas along the coastal zones are also suitable for growing improved pastures. There are heavy concentrations of cattle, sheep and goats in these areas. However, the number of animals in these areas could be increased manyfold as the land is available for agriculture or livestock. Integration of both large and small ruminants with oil palm plantations has been found to be the most ideal production system. This causes no significant problem to the crop. However, animals can damage the leaves in oil palm plantations that are under two years old. A conceptual model for herbal production under oil palm cultivation has been presented (Figure 1). Some of the problems and solutions in forage production in the oil palm-ruminant integrated systems have been identified (Sivaraj et al 1993). These include:

1. Planting grasses and fodder crops in marginal lands in plantations for supplementation and forage conversion .
2. Selection of short varieties of grasses with biomass production.
3. Growing more shade/acid tolerant legumes.
4. Strategic utilisation of crop residue (palm frond and palm trunks).
5. Practising semi-intensive or zero grazing systems where very high rainfall, fluctuating feed supplies and typhoons prevail.

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**Figure 1.** *Conceptual model of herbage production under oil palm cultivation.*

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## Opportunity ahead

One of the major drawbacks in the development of a viable ruminant industry in the past was the lack of effective implementation of knowledge that was generated through research in Malaysia. Integrated operations have never been popular with the managers of plantations as there had been little on-farm research to demonstrate the economic feasibility of the project and the implementation of new technologies (electric fencing for grazing, harvesting of foliage and its pelletisation, conservation of indigenous resources in plantation land, effective utilisation of all by-products as animal feed etc).

In the plantation sector alone (commercial and smallholder plantations), specialised operations such as cow–calf, ewe–lamb and doe–kid production can be instituted in a more structured manner. In view of the current labour shortage in plantations, contract farming to landless farmers or businessmen with animal husbandry backgrounds may be encouraged.

The Malaysian Government has plans to develop strategic partnerships with neighbouring countries for expanding the livestock and poultry industries. A number of auxiliary industries interrelated with livestock, such as food processing, pharmaceuticals etc can also be established through such co-operation.

Small farmers' capital investment capacity needs to be strengthened to encourage them to venture into medium- to large-scale animal production. Subsidies given in the past are not encouraged any more; instead the government plans to build infrastructure to support availability of quality animals, feed, health care and markets. The extensive systems of smallholders will continue to operate, yet their purpose will be to produce specialised products (lean and tasty beef and chicken, processed eggs and meat of medicinal value). On-farm research is necessary to investigate whether these extensive production systems can be tied up with the integrated industrial systems, or some new on-farm technologies should be developed that can alleviate production and marketing constraints at the farm level.

## **Livestock and environment**

The government has recently become very concerned about the environment. The problem of pollution encompasses among others, degradation of the environment due to piggeries and to a lesser extent, poultry wastes. This may cause:

- pollution in receiving streams due to organic wastes consuming all available dissolved oxygen
- development of sludge banks in the vicinity of the waste discharge
- eutrophication
- spread of diseases.

Waste treatment plants and measures to control human exposure to untreated waste are therefore encouraged. Treated waste may be used for crop and fish production. Models of different types of livestock–fish and livestock–fish crop production system are available (Edwards et al 1988; Mukherjee et al 1992).

Centralised pig farming areas (PFA) (Ahmad Mustafa et al 1983), strict implementation of regulations and discharge standards of the Department of Environment, and installation of modular waste treatments (Taiganides 1992), are some of the measures suggested to control pollution from livestock sources. A new farm in a PFA would produce pigs at higher cost which may have to be addressed.

## **Research priorities**

During the recent series of five-year plans (1970–95), Malaysia has developed excellent facilities for agricultural research. During the last five years, the Ministry of Science and Technology supported intensive research for priority areas (IRA) in the agriculture, industry, medical and strategic sectors. The following institutions have developed suitable infrastructure for continuation of research in various areas of livestock. The institutions involved are:

1. Malaysian Agriculture Research and Development Institute (MARDI)
2. Agriculture University of Malaysia (UPM)
3. Veterinary Research Institute (VRI)
4. Institute of Animal Biotechnology, Jerantut
5. Central Institute of Animal Biotechnology, Kluang
6. Universiti Malaya
7. Universiti Kebangsaan Malaysia

During the Seventh Malaysia plan (1996–2000), the priority areas for livestock research have been identified as:

- production efficiency
- breeds and breeding
- reproductive physiology
- diseases (not discussed in this paper)
- nutrition and feed resources
- product handling and food design
- pollution control
- companion, sport and recreation animals.

## **Production efficiency**

The following issues are relevant:

1. Efficient and sustainable production systems need proper management and consideration of resources currently available and the protection of the environment. Sustainable livestock–tree–crops production systems could bring major, positive changes in production efficiency. More research and development projects must be conducted to strengthen benchmark data. Under estate conditions, the constraints to, and motivation for the process of integration ought to be well defined in order to accelerate the involvement of commercial plantations. Economic data is inadequate.
2. Research on heat stress and management of animals in integrated and non-integrated production systems is almost non-existent. This relates to improved housing and automation. Therefore, the effect of environment on animal performance in all classes of livestock and poultry will be an important research area. For intensive livestock and poultry production, environmental stress on parent and commercial stocks should be studied.
3. Nutritional management, control of debilitating diseases and parasites, and livestock production modelling are other areas of research that need to be emphasised.

## **Breeds and breeding**

1. National breeding schemes for beef and dairy cattle, sheep and goats, ducks and Kampung chicken, and deer are to be strengthened. This will be done with research on breeding objectives, evaluation of breed and crossbred groups under similar conditions, choice of selection criteria, further organisation of the performance recording scheme, use of records to assess productive and selection decisions and use of selected individuals. Research on estimation of variance and covariance components using derivative-free REML and future needs in computing strategies are to be initiated.
2. Evaluation of tropical breeds under the Malaysian environment for different classes of ruminants and conservation strategies for endangered indigenous resources (e.g. Malin sheep and Katjang goats) are also considered as top priorities. Live and cryopreservation methods should be evaluated for conservation purposes.

3. Development of locally-adapted, synthetic breeds were a major research area in the past. This work was done by the University of Malaya (dual-purpose goat and hair sheep), MARDI (hair sheep) and the Department of Veterinary Services (Selembu (a cross between cattle and Seladang), hair sheep and cattle). Further research in this area to develop locally adapted, synthetic breeds to suit the major agro-ecological zones, production systems and consumer preference are to be encouraged.
4. Potential of non-conventional animals (deer, turkey and quail) as alternative sources of meat will be investigated. Breeding and selection methods under local conditions need to be studied.
5. There are some quality animals available in different classes of livestock—Friesian, Sahiwal, Jermasia, Kedah Kelantan etc. Improvement of the rate of multiplication through biotechnological methods has to be stressed.

Using advanced biotechnological methods, e.g. gene identification, gene cloning, gene manipulation and transfer will be an important area of research in the Seventh Malaysia plan.

## **Reproductive physiology**

1. To urgently investigate ways of increasing the existing lambing rate of about 110% to about 150% per year, improvement of fertility through nutritional, environmental and endocrinological/pharmacological manipulations of males and females becomes an essential part of research. This also includes reproductive problems during prenatal and post-partum stages.
2. Refinement of reproductive techniques (such as oestrus synchronisation, control of ovulation, embryo transfer, induction of parturition and pregnancy diagnosis) have to be further strengthened.

## **Nutrition and feed resources**

Livestock production improvement in different agro-ecological zones (alluvial planes, bris-soil areas. undulating zones and hilly areas) necessitates increased use of indigenous feed resources using conventional and biotechnological methods. Further stimulation of integrated tree crops–animal systems can be achieved should the feed availability be adequate. The following areas of research in the Seventh Malaysia plan have been suggested.

1. Production of local feed crops (in particular cassava, sweet potato and sago) has declined in the past few years. Research on the availability of additional land for this purpose, improved seed stock and novel management methods are to be emphasised.
2. Adequate by-products from oil palm and rubber mills are available which can currently sustain at least 10 million head of ruminants; there are only 110,149 head of buffalo, 611,667 beef cattle, 77,621 dairy cattle, 227,065 goats and 244,023 sheep (Ministry of Agriculture 1993). Hence the following areas of research will receive top priority:
  - Improvement of handling, processing and utilisation of oil palm by-products (in particular palm kernel cake and oil palm fronds).
  - Further research on rice by-products (rice bran and rice straw in particular).

- By-products of poultry processing and fruit processing plants.
3. Considerable diversity exists in the types of forage supplements available in commercial and smallholder plantations, and around village farms. Research towards the proper management and utilisation of fodder/forage crops for integrated feedlot schemes for beef, dairy and small ruminant production should be undertaken.
  4. Appropriate feed formulation and feeding strategies need to be extensively investigated. This includes determination of nutrient requirements of different species and physiological stages of livestock.
  5. Rumen ecology and metabolism research to improve utilisation of feed under tropical conditions began in the 6th Malaysia plan. This needs further emphasis along with studies on characterisation and manipulation of rumen microbes.

## **Product handling and food design**

The following research areas have been suggested:

- Food design concept for production of healthy produce.
- Wholesome livestock and poultry produce (considering microbiological, drug residue and toxic components) .
- Effects of stress on carcass grade and quality.
- Innovative products from livestock and poultry produce.
- Development of Malaysian standards for meat and meat products.

## **Pollution control**

The Department of the Environment has drawn up stringent rules and regulations regarding the contamination of environment by pollutants including animal wastes. The following research areas have been recommended .

1. Pollution abatement from intensive livestock and poultry production (engineering design, use of biotechnological products—effective microbes, deodorisers etc) and other auxiliary industries.
2. Development of environment impact assessment guidelines for livestock projects.

## **Companion, sport and recreational animals**

The research areas include:

- epidemiology of zoonotic disease such as rabies, their control and eradication
- demography of stray dog/cats and their control
- pathogenesis, development of diagnostics and development of treatment protocol for skin diseases
- factors affecting the course of bone and joint diseases and the dynamics of using hardware in their treatment
- reconstructive surgery and drug trials on ophthalmological cases
- reproductive disease

- production of pet food.

Sports and recreation animal research encompasses formulation of new feed for horses using local products, studies of horse disease under tropical environments, and cross breeding and upgrading of local indigenous horses for size and performance.

While formulating the above research programmes, the committee recommended stronger institutional linkages and reviewing of policy issues on import, tariffs and trade by the policy makers. In addition, some innovative technologies required have been adequately emphasised to revolutionise the ruminant industry.

## Conclusion

The Malaysian Government's policy is to support the production of quality food products at competitive prices using environmentally friendly and sustainable production systems which also enhance quality of life. Thus, the improvement of animal production has to be carefully designed. This needs thorough scientific and technological innovations which cannot be accomplished without adequate research facilities and manpower. Thus, the Seventh Malaysia plans allocation for research in the livestock sector should be considerably higher than the similar allocations in the Sixth Malaysia plan.

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## Discussion following Dr Mukherjee's paper

Vo-Tong Xuan: We know that Malaysia is a country based on agricultural exports and has the highest total per capita GNP. This is the forward thinking of the Government of Malaysia where food self-sufficiency is not the goal. They continue to import food not depending on self-sufficiency. The country is largely Muslim, so the expertise in goat and sheep husbandry is unbeatable in Asia. So the problems there are very specific.

Sasaki: I am not sure if Dr. Mukherjee considers himself as an agricultural research scientist but even now he is doing very basic research. I feel that if we concentrate too much on applied research, like the whole CG group is doing currently, you may lose the technology of excellence. If you concentrate too much on the systems approach you may not attract scientists of excellence. I believe, particularly that in the veterinary health and animal health sectors you still need types of very basic research to develop technologies which will ultimately benefit the poor.

My feeling is that the CGIAR gives too much emphasis to extension, direct benefit to the farmer etc, and yet for some biotechnologies you do need very basic research. If this kind of trend continues probably the so called animal biotechnology cannot be done by the CGIAR.

Fitzhugh: These days in most of the world it's difficult to find support for agricultural development. Now we are in a region where agricultural development is seen as being important for growing populations which need more food. The representative from the Asian Development Bank pointed out what they were doing for agricultural development but still it is difficult to argue it in many places. Support for agricultural research is even more difficult to find. Even in this region support for the more fundamental areas of research uncovering basic knowledge, basic understanding of fundamental systems, is actually being supported reasonably well in some places as long you look for that research which focuses on problems of humans—human health in particular, cancer research, AIDS. I think we must have agricultural development. I think that research is essential to the success of agricultural development, I think that we have to be much more innovative in identifying where we will call for knowledge to come in and support the more applied research to agricultural development. So increasingly, scientists will find that they are having to bridge the gap between the very fundamental research going on related to human problems to really focus on the things that we are interested in. So as agricultural scientists, this will increasingly be our role. It is going to be more difficult to get direct support for us to do fundamental type research activities, but as long as we can keep a close interface and the quality of our own knowledge about what is going on inside science, we will be able to pull out of the more basic areas and then apply it to the needs that we identify, then I think we will be doing our job.

Mukherjee: Many of the organisations now would like to see a kind of research which is done on a cost-sharing basis. You pay some, and I pay some, and then we do the research of common interest. Things as you say,

must be innovative in terms of the research formulation and must be reviewed by a strong independent body.

The other thing I would like to note is that the university professors and researchers roles are changing in the developing world, tending towards social/economic type of research. They also have to be in line with the policy of making business. ILRI can also look into this possibility and examine the commercial possibilities of research results, and see whether you can get incentives from the Bank or from other financial organisations. I think all the Banks and financial organisations in many countries, not just Malaysia, are also looking for projects which can actually make money for the farmers and for the research organisations.

# The Philippine livestock industry: The research and development agenda

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## Abstract

The research and development agenda of the Philippine livestock industry is presented with reference to the contribution of this subsector to agriculture, available resources, and the medium-term livestock development plan. The livestock and poultry sectors had a significant growth rate between 1984 and 94, and in 1994 recorded annual growth rates of between 3.0–4.8%, in which the poultry and swine subsectors were at the forefront. Land use systems are of four categories: food crops, coconuts, grasslands and forests, in which intensive cultivation of crops accounted for about 32% of the total land area. The medium-term livestock development plan has the following programmes: breeding cattle, dairy, carabao, small ruminants, poultry, pigs and other components such as stock farm development. The research development priorities for the livestock sector within the plan are in order of importance: animal health, genetic resources and biodiversity, production systems research, feed resources, product development, technology transfer, and policy advocacy and socio-economic studies. The national research and development network and linkages are described.

## Introduction

Agriculture continues to be the backbone of the Philippine economy, and it contributes significantly to the country's national income. The agricultural sector accounted for 23% of the gross national product (Table 1) and 21% of the total merchandised export (Table 2) in 1990. This sector was a major source of employment, absorbing more than 40% of the country's total labour force (Table 3).

The growth rates of the agriculture sector during the last decade showed an erratic trend (Table 4). The strong performance of the livestock and poultry subsectors from 1985 to 1990 contributed significantly to the overall growth rate. However, such growth has not been sustained given the available resources (i.e. availability of corn, infrastructure etc) and existing policies (i.e. distribution of price systems, support to livestock programmes etc), which resulted in the retarded growth rate of the livestock subsector during the early 1990s. This contributed to the reduced growth rate in the agriculture sector (Mellor 1993); from 1993 to 1994, the agriculture sector grew by only 3.2% (BAS 1995). The livestock and poultry subsectors grew by 4.8% and 3.0%, respectively, during the same period.

An indicator of good economic performance is an 8.0% growth rate in the livestock subsector. This rate would double the sector's absolute size every 10 years and would, therefore, substantially increase its contribution to the agriculture economy (Mellor 1993).

**Table 1.** *Contribution of agriculture and natural resources to gross national product (GNP), the Philippines (1980–90, Pesos x 10<sup>6</sup>).*

| Year | Gross value in agriculture (GVA) | Gross Domestic Product (GDP) | Gross National Product (GNP) | Per cent contribution of GVA to agriculture |        |
|------|----------------------------------|------------------------------|------------------------------|---------------------------------------------|--------|
|      |                                  |                              |                              | To GDP                                      | To GNP |
| 1980 | 61,761                           | 264,650                      | 264,532                      | 23.33                                       | 23.35  |
| 1981 | 69,391                           | 305,258                      | 303,628                      | 22.73                                       | 22.85  |
| 1982 | 76,721                           | 340,597                      | 335,435                      | 22.52                                       | 22.87  |
| 1983 | 84,546                           | 384,096                      | 378,746                      | 22.01                                       | 22.32  |
| 1984 | 139,505                          | 540,466                      | 527,355                      | 25.81                                       | 26.45  |
| 1985 | 162,519                          | 612,684                      | 597,743                      | 26.52                                       | 27.19  |
| 1986 | 155,989                          | 627,129                      | 614,703                      | 24.87                                       | 25.38  |
| 1987 | 170,770                          | 708,368                      | 703,361                      | 24.11                                       | 24.28  |
| 1988 | 190,153                          | 825,852                      | 822,870                      | 23.02                                       | 23.11  |
| 1989 | 226,698                          | 964,535                      | 961,914                      | 23.50                                       | 23.57  |
| 1990 | 2,619,401                        | 1,298,171                    | 132,404                      | 23.18                                       | 23.13  |

Source: National Statistical Yearbook (1991).

**Table 2.** *Contribution of agriculture and forestry sectors to foreign trade—1981 to 1990 (FOB values and US\$ x 10<sup>6</sup>).*

| Year | Total merchandise export (1) | Agriculture |                         | Forestry   |                         |
|------|------------------------------|-------------|-------------------------|------------|-------------------------|
|      |                              | Export (2)  | % of total export (1/2) | Export (3) | % of total export (3/4) |
| 1981 | 5270                         | 1880        | 32.86                   | 469        | 8.20                    |
| 1982 | 5021                         | 1576        | 31.39                   | 362        | 7.21                    |
| 1983 | 5005                         | 1410        | 28.17                   | 331        | 6.61                    |
| 1984 | 5391                         | 2584        | 29.38                   | 323        | 5.99                    |
| 1985 | 4629                         | 1119        | 24.17                   | 346        | 7.47                    |
| 1986 | 4842                         | 1460        | 30.15                   | 251        | 5.18                    |
| 1987 | 5720                         | 1522        | 26.61                   | 306        | 5.35                    |
| 1988 | 7074                         | 1713        | 24.22                   | 339        | 4.79                    |
| 1989 | 7821                         | 1708        | 21.84                   | 284        | 3.63                    |
| 1990 | 8186                         | 1701        | 20.48                   | 95         | 1.16                    |

Source: BAS and National Statistical Office (1991).

**Table 3. Total population, labour force and employment in agriculture (1980–90, millions of people).**

| Year | Total population | Total labour force | Total employment in agriculture |
|------|------------------|--------------------|---------------------------------|
| 1980 | 48.09            | 17.31              | 8.45                            |
| 1981 | 49.45            | 18.54              | 8.93                            |
| 1982 | 50.78            | 18.47              | 8.92                            |
| 1983 | 52.05            | 20.31              | 9.88                            |
| 1984 | 53.35            | 20.97              | 9.74                            |
| 1985 | 54.67            | 21.32              | 9.70                            |
| 1986 | 56.01            | 22.07              | 10.29                           |
| 1987 | 57.36            | 22.99              | 10.01                           |
| 1988 | 58.72            | 21.50              | 9.92                            |
| 1989 | 59.86            | 22.20              | 10.15                           |
| 1990 | 60.68            | 23.09              | 10.35                           |

Source: National Statistical Office (1990).

**Table 4. Agricultural growth rates by subsectors (1982–94).**

| Item                | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1993 | 1994 |
|---------------------|------|------|------|------|------|------|------|------|------|------|------|
| Agricultural sector |      |      |      |      |      |      |      |      |      |      |      |
| Growth rate (%)     | 4.1  | -1.5 | 2.6  | 3.5  | 4.0  | 1.5  | 3.4  | 4.3  | 2.4  | 2.8  | 3.2  |
| Subsectors          |      |      |      |      |      |      |      |      |      |      |      |
| Crops               | 3.3  | 6.1  | 4.2  | 5.4  | 4.6  | -4.8 | 1.1  | 2.4  | 1.1  | 1.3  | 3.4  |
| Livestock           | 4.3  | 8.1  | -0.4 | -2.2 | 8.0  | 6.5  | 8.8  | 10.4 | 8.1  | 4.8  | 4.8  |
| Poultry             | 12.0 | 13.2 | 4.4  | -0.5 | -1.1 | 7.7  | 11.4 | 9.6  | 9.4  | 6.0  | 3.0  |
| Fishery             | 3.0  | 3.6  | -8.5 | 62.1 | 2.9  | 1.9  | 4.2  | 6.2  | 4.4  | 1.3  | 1.7  |

Sources: BAS (1990, 1995).

## Available resources

Annexes 1 to 5 present a brief analysis of the livestock industry by commodities. The poultry and swine sectors continue to be at the forefront of the industry. The two species showed a stable inventory of 60 million birds and 8 million hogs between 1983 and 1992. It is important to note, however, that about 75–80% of these animals were raised by smallholders (Tables 5 and 6). The duck population is presented in Table 7. The birds were also essentially raised by smallholder farmers.

**Table 5.** *Chicken population.*

| Year  | Population (x10 <sup>3</sup> ) |            |        |
|-------|--------------------------------|------------|--------|
|       | Backyard                       | Commercial | Total  |
| 1983  | 42,041                         | 20,213     | 62,254 |
| 1984  | 40,476                         | 18,685     | 59,161 |
| 1985  | 39,339                         | 13,059     | 52,398 |
| 1986  | 40,269                         | 12,737     | 53,006 |
| 1987  | 40,461                         | 12,787     | 53,248 |
| 1988  | 43,163                         | 17,158     | 60,321 |
| 1989  | 47,105                         | 18,807     | 65,912 |
| 1990  | 48,628                         | 20,900     | 69,528 |
| 1991  | 46,634                         | 18,846     | 65,480 |
| 1992  | 47,370                         | 15,757     | 63,127 |
| 1993* | 46,632                         | 18,236     | 64,868 |

\*Preliminary estimates.

Source: BAS (1983–1994).

**Table 6.** *Swine population.*

| Year  | Population (x10 <sup>3</sup> ) |            |       |
|-------|--------------------------------|------------|-------|
|       | Backyard                       | Commercial | Total |
| 1984  | 6359                           | 1253       | 7612  |
| 1985  | 5998                           | 1306       | 7304  |
| 1986  | 6081                           | 1194       | 7275  |
| 1987  | 5920                           | 1118       | 7038  |
| 1988  | 6312                           | 1268       | 7580  |
| 1989  | 6677                           | 1232       | 7909  |
| 1990  | 6776                           | 1214       | 7990  |
| 1991  | 6621                           | 1458       | 8079  |
| 1992  | 6717                           | 1305       | 8022  |
| 1993  | 6663                           | 1290       | 7953  |
| 1994* | 6766                           | 1460       | 8226  |

\*Preliminary estimates.

Source: BAS (1983–1994).

**Table 7.** *Duck population.*

| Year  | Population (x10 <sup>3</sup> ) |            |       |
|-------|--------------------------------|------------|-------|
|       | Backyard                       | Commercial | Total |
| 1984  | 4527                           | 1234       | 5761  |
| 1985  | 4345                           | 876        | 5221  |
| 1986  | 4507                           | 701        | 5208  |
| 1987  | 4733                           | 519        | 5252  |
| 1988  | 5116                           | 717        | 5833  |
| 1989  | 5663                           | 838        | 6501  |
| 1990  | 6374                           | 862        | 7236  |
| 1991  | 7418                           | 850        | 8268  |
| 1992  | 7661                           | 679        | 8340  |
| 1993  | 7975                           | 531        | 8506  |
| 1994* | 7585                           | 602        | 8187  |

\*Preliminary estimates.

Source: BAS (1983–1994).

Sheep and goats (small ruminants) were integral parts of smallholder farming systems. Goats exhibited positive growth rates throughout the period (2.2 million in 1982 to 1992). Sheep rearing, however, needs further promotion among smallholder farmers as they number only about 30–40 thousand head. The population statistics for goats are shown in Table 8.

**Table 8.** *Goat population.*

| Year  | Population (x10 <sup>3</sup> ) |            |       |
|-------|--------------------------------|------------|-------|
|       | Backyard                       | Commercial | Total |
| 1984  | 2329                           | 33         | 2362  |
| 1985  | 2159                           | 32         | 2191  |
| 1986  | 2148                           | 29         | 2177  |
| 1987  | 1997                           | 19         | 2016  |
| 1988  | 2103                           | 17         | 2120  |
| 1989  | 2196                           | 16         | 2212  |
| 1990  | 2178                           | 14         | 2192  |
| 1991  | 2109                           | 13         | 2122  |
| 1992  | 2294                           | 13         | 2307  |
| 1993  | 2552                           | 10         | 2562  |
| 1994* | 2622                           | 9          | 2631  |

\*Preliminary estimates.

Source: BAS (1983–1994).

The populations of cattle and carabao of about 1.7 millions and 2.6 millions, respectively, in 1992 were generally kept by smallholder farmers. The high extraction rates, low productivity and small breeding base resulted in the continuing decline of these large ruminant populations (Tables 9 and 10).

**Table 9.** *Cattle population.*

| Year  | Population (x10 <sup>3</sup> ) |            |       |
|-------|--------------------------------|------------|-------|
|       | Backyard                       | Commercial | Total |
| 1984  | 1512                           | 337        | 1849  |
| 1985  | 1493                           | 294        | 1787  |
| 1986  | 1504                           | 311        | 1815  |
| 1987  | 1496                           | 251        | 1747  |
| 1988  | 1489                           | 211        | 1700  |
| 1989  | 1503                           | 179        | 1682  |
| 1990  | 1441                           | 189        | 1630  |
| 1991  | 1485                           | 191        | 1676  |
| 1992  | 1577                           | 153        | 1730  |
| 1993  | 1754                           | 160        | 1914  |
| 1994* | 1753                           | 169        | 1922  |

\*Preliminary estimates.

Source: BAS (1983–1994).

**Table 10.** *Carabao population.*

| Year  | Population (x10 <sup>3</sup> ) |            |       |
|-------|--------------------------------|------------|-------|
|       | Backyard                       | Commercial | Total |
| 1984  | 3014                           | 8          | 3022  |
| 1985  | 2973                           | 10         | 2983  |
| 1986  | 2974                           | 11         | 2985  |
| 1987  | 2855                           | 10         | 2865  |
| 1988  | 2881                           | 9          | 2890  |
| 1989  | 2836                           | 5          | 2841  |
| 1990  | 2759                           | 6          | 2765  |
| 1991  | 2642                           | 4          | 2646  |
| 1992  | 2572                           | 4          | 2576  |
| 1993  | 2570                           | 5          | 2575  |
| 1994* | 2555                           | 4          | 2559  |

\*Preliminary estimates.

Source: BAS (1983–1994).

Essentially, livestock and poultry are raised in the upland areas of the country, with the exception of carabaos, which are also raised in the lowland rice areas to provide draft power requirements. The land use systems in the upland areas (Table 11) where livestock is a component could be categorised for the Philippines as follows (Garrity and Sajise 1990):

*Food crop systems.* These systems predominantly produce upland rice, maize and root crops, particularly sweet potato. The by-products of these crops could support sizeable livestock poultry populations.

*Coconut-based systems.* The country has the worlds largest area devoted to coconut covering nearly one-sixth of the land area. Other tree plantations include rubber, mango, citrus and jackfruit (Table 12). The livelihood of millions of poor families depends on the coconut industry, thus integration of livestock and poultry could provide additional income to families living in these areas.

*Grassland systems.* Traditionally, these areas are used for cow calf operations. These extensive areas are the result of deforestation, brush fires and shifting cultivation for the production of food crops.

*Forest plantations.* Declining natural forest seriously affected the ecosystem, particularly the country's watershed areas. Likewise, these natural resources could no longer provide the populace with the required wood and wood products for housing and energy. These conditions necessitate the establishment of forest plantations where integration of livestock and poultry as livelihood projects and as a source of food were reported to be feasible.

The positive growth rates of the commercial livestock and poultry sectors, in particular, have been associated with the positive growth rates in corn production (Table 13). Corn is the major feed ingredient of hog and poultry rations. In 1994, corn production exhibited a negative growth rate of -5.8%. As shown in Table 4, livestock and poultry production growth rates, similarly, decreased to 3.9% in 1994.

The Philippines is potentially a low-cost producer of corn; to date the corn yield is low although the potential for increasing it is good. The Corn Enhancement Programme hopes to correct the various constraints to high productivity.

**Table 11.** *Classification of land use in the Philippines.*

| Land use                                                                                                   | Area<br>(‘000 ha) |
|------------------------------------------------------------------------------------------------------------|-------------------|
| Forest (pine, mossy/unproductive, dipterocarp, closed, open and mangrove)                                  | 7226              |
| Extensive cultivation (open forest, grassland and mixed <sup>1</sup> )                                     | 11,957            |
| Intensive cultivation (plantation, coconut, other, coconut and cropland, other and cropland, and cropland) | 9729              |
| Fishponds (fishponds from mangrove, and other fishponds)                                                   | 205               |
| Other land/lakes                                                                                           | 542               |
| Unclassified area                                                                                          | 546               |
| Total                                                                                                      | 30,205            |

1. Mixed grass, brush, plantation and other crops.

Source: Garrity et al (1992).

**Table 12.** *Crop area of selected tree crops (in 1988).*

| Tree crop | Area ('000 ha) |
|-----------|----------------|
| Coconut   | 3400.00        |
| Rubber    | 75.71          |
| Mango     | 62.78          |
| Citrus    | 25.28          |
| Jackfruit | 13.00          |
| Total     | 3576.77        |

Source: NAREA (1989).

**Table 13.** *Average annual growth rates of real percentage value added in agriculture by commodity (1965–90, 1994).*

| Item                   | 1965–90 | 1980–90 | 1994 |
|------------------------|---------|---------|------|
| All agricultural crops | 4.4     | 1.6     | 3.2  |
| Rice                   | 3.2     | 2.0     | 11.7 |
| Corn                   | 4.8     | 3.7     | -5.8 |
| Coconut                | 2.8     | 3.1     | -0.6 |
| Sugar-cane             | -0.4    | -6.9    | 3.1  |
| Livestock and poultry  | 4.2     | 5.8     | 3.9  |

Source: BAS (1983–1994).

## The Philippine's Medium Term Livestock Development Plan

The Philippine livestock development programme is embodied in the Medium Term Livestock Development Plan (MLTDP) for 1993–1998 developed by the Department of Agriculture. It lays the foundation for a productive and sustainable livestock industry. The Plan is anchored on specific commodity programmes while moving holistically toward the development of the livestock industry. An integrated approach is being followed in the course of its implementation. The component programmes are as follows:

- The breeding cattle development programme. The programme aims to double the beef cattle population to 3.0 million.
- The dairy programme. Within the programme period, a total of 216 dairy co-operatives with 5000–6000 members will be organised; 37,500 head of dairy animals will be infused.
- The carabao programme. This programme hopes to stabilise the carabao population to 2.5 million. Likewise, the programme shall harness the full potential of the carabao as a milk and meat animal which will, at the same time, contribute to the beef supply,
- The small ruminant programme. The programme's target is to increase the population of sheep and goats to 3.4 million, primarily to be raised by smallholder farmers as an economic project integrated in its farming operation.

- The poultry programme. The priority activities are designed to assist the initiatives led by the private sector. The programme shall likewise attend to the conservation and improvement of indigenous chickens and ducks.
- The pig programme. This programme will focus on the development of new markets for its products.
- Other component programmes. These include the stock farm development programme, quarantine station and animal health. Post production and market support programmes will be enhanced.

The research and development programme of the National Agriculture and Resources Research and Development Network (NARRDN) supports the technology needs and the development strategies of the above programmes.

## **Research and development programme**

The development in the livestock and poultry industries has been due, in part, to the efforts of the research and development sector. This sector, through the years, has generated and packaged scientific and technical information and technologies for the production of better-producing and more efficient animals, improved management, i.e. appropriate herd health programme, use of least cost feed, correct feeding programme etc.

Research and development resources are limited. It is, therefore, necessary to plan carefully and allocate its funds and manpower resources to derive optimum benefits for the endeavour. The Department of Science & Technology (DOST) in PCARRD, which is the NARRDN secretariat is mandated to exercise central leadership and co-ordination of the research and development efforts and ascertain that research and development results are utilised to attain optimum economic and social benefits.

## **Formulation of research and development framework and priority areas**

One of the primary functions of PCARRD is to develop the research and development plans and framework to prioritise research and development projects. This is achieved through consultations and collective efforts of multi-agency, multidisciplinary teams and a pool of experts. The priority research and development areas identified (1995–2000) are presented in Table 14. Biotechnology as a programme focused its activities on animal health, reproduction and breeding, and feed resources.

**Table 14.** *The priorities for the livestock sector in the Medium Term Research and Development Plan (MTRDP) for 1995–2000.*

| Priorities                                                                                      | Priority commodities                  |
|-------------------------------------------------------------------------------------------------|---------------------------------------|
| Animal health                                                                                   | All livestock commodities             |
| Control and eradication of foot-and-mouth disease (FMD)                                         |                                       |
| Control and eradication of economically important diseases of swine and ruminants               |                                       |
| Rational use of biologics/drugs commodities                                                     |                                       |
| Genetic resource and biodiversity                                                               |                                       |
| Characterisation, conservation and improvement of indigenous livestock and forage crops         | All livestock                         |
| Production systems research                                                                     |                                       |
| Commercial farms                                                                                | Swine, poultry and cattle commodities |
| Monitoring of production performance of selected farms                                          |                                       |
| Waste management                                                                                |                                       |
| Smallholder farms                                                                               | All livestock commodities             |
| Integrated total farm systems analysis                                                          |                                       |
| Industry profile/state of the art projects                                                      | All livestock commodities             |
| Feed resources                                                                                  | Ruminant commodities                  |
| Development of technologies and strategies to promote consistent feeding among ruminant animals |                                       |
| Performance trials of forage crops                                                              |                                       |
| Product development                                                                             | All commodities                       |
| Meat and meat products                                                                          |                                       |
| Dairy                                                                                           |                                       |
| Technology transfer                                                                             | All commodities                       |
| Technology promotion                                                                            |                                       |
| Technology commercialisation/incubator                                                          |                                       |
| Applied communication                                                                           |                                       |
| Management information systems                                                                  |                                       |
| Policy advocacy and socio-economic studies                                                      | All commodities                       |

Annexes 1 to 5 also indicate the constraints to the development of the various livestock commodities. It may be noted that the control and eradication of economically important diseases of swine, poultry and ruminant animals are major concerns. Likewise the lack, or high costs, of quality breeding animals, including other vital production inputs such as corn, biologics and supplements, the unavailability of better technologies and market infrastructures etc, suppress the development of the livestock industry. The research and development framework and the developmental programmes of the subsector are summarised in the annexes.

In the packaging of the MTRDP, four government departments were directly consulted to dovetail the research and development efforts to their development projects. These departments are pursuing flagship programmes and/or development approaches. For example the Department of Agriculture with its Key Production Area (KPA) approach; the Department of Science and Technology

(DOST) with its Science and Technology Agenda for National Development (STAND) 2000; and the Department of Environment and Natural Resources (DENR) and the Department of Education, Culture and Sports (DECS) with their medium-term thrusts and priorities. In the Implementation of the MTRDP, the collaborative relationships among research and development institutions is reinforced and their effectiveness enhanced through networking among themselves and broadening linkages with the private sector.

A stronger co-ordination with the private sector and its resources and the major NARRDN livestock stake in activities, opens a haven of opportunities and complementation towards raising and implementing focused projects. Specific examples of these projects are: monitoring of production efficiency, biodiversity, conservation and use of indigenous livestock species, biotechnology for livestock production and health, and control and eradication of foot-and-mouth disease (FMD).

The farmers remain the ultimate beneficiaries of technology generation and transfer of programmes. The NARRDN, with PCARRD as the national secretariat and co-ordinating council, endeavours to conduct research and development programmes responsive to farmers' needs and to move research and development outputs closer to these clients.

## **The national research and development network**

PCARRD established the National Agriculture and Resources research and development Network (NARRDN) for ruminant, pork and poultry commodities among others. The NARRDN (Table 15) is composed of agencies conducting research and technology transfer and promotion (for development). It is composed of national and regional centres of excellence and co-operating stations.

**Table 15.** *Livestock research and development centres of excellence/network 1993.*

| Commodity | National centres                                                                                                                            | Regional centres                                                    |
|-----------|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Ruminants | UPLB (carabao <sup>1</sup> , cattle, small ruminants, forage, pasture and grasslands)<br><br>CLSU (carabao, forage, pasture and grasslands) | ISU (carabao; forage pasture and grasslands)                        |
|           |                                                                                                                                             | USF (carabao, cattle; forage, pasture and grasslands)               |
|           |                                                                                                                                             | CMU (carabao <sup>2</sup> , cattle, forage, pasture and grasslands) |
|           |                                                                                                                                             | CLSU (cattle; small ruminants, forage, pasture and grasslands)      |
|           |                                                                                                                                             | ViSCA (small ruminants; forage, pasture and grasslands)             |
|           |                                                                                                                                             | USM (small ruminants, forage, pasture and grasslands)               |
| Swine     | UPLB                                                                                                                                        | DMMSU<br>ViSCA<br>USM                                               |
| Poultry   | UPLB                                                                                                                                        | ISU<br>WVSU<br>USM                                                  |

1. The research and development centre and stations of the Department of Agriculture including other livestock member institutions of the NARRDN serve as co-operating stations. These centres are members of the regional consortium.
2. The Philippine Carabao Centre based in the SCUS.

The national centre conducts basic and applied research of national interest in one or more commodities. The centre is also mandated to package and disseminate scientific and technical information and technologies. The regional centres of excellence, however, conduct applied research and development for commodities that are important in their areas of responsibilities (flagship/banner project). They are also mandated to validate the research findings of the national centre, and to package, promote and transfer appropriate information and technologies.

The research and development stations of the Department of Agriculture, and state colleges and universities with funds for livestock research and development projects, serve as co-operating institutions. These stations are mandated to package, promote and transfer appropriate information and technologies to various clients. These stations are called on to implement applied research and development on project basis.

The NARRDN is consistently strengthening the regional research and development network. The implementation of banner projects on selected technologies enhances the capabilities of the regional network in effectively promoting research results. It also allows the scientific and technical sector to gauge the pulse of the farmer-clients which is necessary for various planning exercises.

## Linkages

The NARRDN pursues aggressive research and development linkages with the local and international research and development centres/stations. The substance

of such linkages is attuned to the research and development framework. Some of the areas being currently pursued are:

- Feed resources/forage seed production with CIAT, the Australian International Development Assistance Bureau (AIDAB) and the Food and Agriculture Organization of the United Nations (FAO).
- Animal health, animal-product processing, biodiversity, genetic conservation and utilisation with FAO.
- Information systems with the Commonwealth Agricultural Bureaux International (CABI) and International Development Research Centre (IDRC).
- Animal biotechnology with FAO and the Association of South-East Asian Nations (ASEAN) national research and development system.
- Animal improvement with the Japanese International Cooperation Agency (JICA).

The NARRDN has fruitful collaborations with international organisations. As an example, the Philippine Carabao Centre (PCC) was a project supported by FAO. The support involved assisting the Philippine government to strengthen the Philippine carabao research and development network through its manpower capabilities and infrastructure. In 1992, the President of the Republic of Philippines signed into law the bill creating the PCC. The PCC is responsible for the development of the carabao industry (see Cruz, this proceedings).

## **Concluding remarks**

The priority research areas to be addressed by the Philippine NARRDN are animal health, genetic resources and biodiversity, production systems, feed resources and product development. Similarly, the NARRDN will focus its development mandate on technology transfer using strategies where risk-taking will be generally assumed by the research and development system rather than by farmers or entrepreneurs. Lastly, the system will provide policy makers and planners with information they can use as a basis for policy formulation.

The PCARRD–DOST is the secretariat of the Philippine NARRDN. It is mandated to exercise central leadership and co-ordination in the implementation of the livestock research and development programme. The research and development projects are being implemented by the research centres/stations, i.e. state colleges and universities, the departments of Environment and Natural Resources (DENR) and Science and Technology (DOST), selected private farms etc.

The livestock research and development programme is developed through consultations and therefore is the result of collective efforts of the various sectors of the industry. The research and development results are packaged and delivered to the doorstep of the various clients.

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# **The Philippine poultry (chicken) industry**

The poultry sector continues to be at the forefront of the livestock industry. Together with the swine sector it has already reached the stage where small-scale and commercial producers can efficiently operate. In 1992, 652,000 t live weight of chicken valued at Pesos 34 billion were produced. Also, the poultry sectors gross value added (GVA) in agriculture increased by 10.5 billion in 1988 to Pesos 26 billion in 1992.

## **Inventory**

- stable inventory (1983–1992) at about 60 million (0.4% per year, average growth rate)
- 72% of the total inventory are in the backyard farms while 28% are in commercial farms.

## **Supply and demand situation**

- increase in meat supply/demand from 168,000 t in 1982 to 250,000 t in 1991 (4.86% per year, average growth rate)
- increase in egg supply/demand from 148,000 t in 1982 to 172,000 t in 1991 (2.5%/yr average growth rate); egg demand increased from 136,000 t in 1982 to 159,000 t in 1991 (2.6% per year, average growth rate)
- while the average per capita meat consumption increased from 3.31 kg in 1982 to 3.98 kg in 1991, average per capita egg consumption remains constant at about 2.5 kg per year.

## **Competitive advantages**

- increasing demand for poultry meat and eggs
- poultry is an efficient converter of feed into. high value protein food products short production cycle
- technologies, facilities, and other inputs for increased productivity and efficiency are available.

## **Problems**

- unabated spread of diseases
- continuous importation of breeding stock
- dependence on imported feed ingredients (e.g. corn and soybean oil meal) and feed additives
- limited availability and high cost of biologics, antibiotics, and other medicines, especially to small farmers
- inefficient marketing system
- poor grading and standardisation system especially in eggs

- lack of infrastructure support.

## **Vision**

- minimise importation of breeder stock
- increase local production of feed ingredients
- minimise losses due to disease and parasitism improve price and market information system
- improve production efficiency and reduce production cost.

## **Proposed interventions**

- review current policies on importation
- strict quarantine procedures and effective disease control/eradication programmes
- increase local corn production through improved post harvest and transport facilities
- improve marketing/pricing system
- develop grades/standards for live animals, carcasses, and other animal products.

# **The Philippine swine industry**

The swine industry (along with poultry) has consistently dominated other livestock industries in terms of volume and value of production. In 1992, 1.06 million tonnes live weight of hog, valued at Pesos 41 billion, were produced.

As a major component of the livestock sector, it has helped raise the contribution of the latter to the gross value added (GVA) in agriculture from Pesos 18.4 in 1988 to Pesos 40 in 1992.

## **Inventory**

- stable inventory (1983–1992) at about 8 million (0.13% per year, average growth rate)
- backyard farms account for 83% of the total inventory; 17% are in commercial farms.

## **Supply and demand situation**

- increase in pork supply from 566,000 t in 1983 to 846,000 t in 1992 (5% per year, average growth rate)
- increase in pork demand from 474,000 t in 1983 to 692,000 t in 1992 (4.8% per year, average growth rate)
- increase in average per capita pork consumption from 9.1 kg in 1983 to 10.8 kg in 1992.

## **Competitive advantages**

- increasing demand for pork
- swine is an efficient converter of feed into high value protein food product
- short production cycle
- technologies, facilities, and other inputs for increased productivity and efficiency are available.

## **Problems**

- unabated spread of economically important diseases
- need to continuously import breeding stock
- dependence on imported feed ingredients (e.g. corn and soybean meal) and feed supplements
- limited availability and high cost of biologics, antibiotics, and other medicines, especially to small farmers
- low farm productivity compared with Asian neighbours inefficient marketing system lack of infrastructure support.

## **Vision**

- minimise importation of breeder stock increase local production of feed ingredients minimise losses due to disease and parasitism improve price and market information system
- improve production efficiency and reduce production cost.

## **Proposed interventions**

- review current policies on importation
- strict quarantine procedures and effective disease control/eradication programmes increase local corn production through improved post-harvest and transport facilities improve marketing/pricing system develop grades/standards for live animals and carcasses
- improvement of genetic quality of local pigs through artificial insemination (AI) and cross breeding.

## **The Philippine small ruminant industry**

Small ruminants (goats and sheep) are an integral part of smallholder farming systems. While goats are already established as a good source of meat (chevon) and milk, sheep are relatively new requiring further attention in terms of promotion.

The goat's popularity as a "poor man's cow" boosted its total production from 37,000 t live weight (valued at Pesos 180 million) in 1983 to 60,000 t live weight (value at Pesos 1.8 billion) in 1992. In contrast, the volume of local sheep production is being complemented by imported mutton.

### **Inventory**

- increase in goat inventory from 1.86 million in 1983 to 2.24 million in 1992 (2.5% per year, average growth rate); current sheep population is estimated to be 30,000–40,000 head
- 99% of the total goat inventory is found in backyard farms while sheep are mostly owned by affluent farmers.

### **Supply and demand situation**

- increase in chevon supply from 28,000 t in 1983 to 37,000 t in 1992 (3% per year, average growth rate)
- increase in chevon demand from 23,000 t in 1983 to 28,000 t in 1992 (2.7% per year, average growth rate)
- average annual per capita chevon consumption remains constant at about 0.45 kg.

### **Competitive advantages**

- increasing demand for chevon and mutton
- requires only a small initial investment and risk of loss is small
- can be easily integrated with other crop-based farming systems
- small ruminants ability to utilise cellulosic feed materials and to survive in marginal environment
- short gestation period which allows meat and milk production in relatively shorter time
- technologies, facilities, and input for increased productivity and efficiency are available.

### **Problems**

- lack of quality breeder stock
- high mortality rate at preweaning stage
- spread of diseases and parasites

- need to promote sheep as an economic commodity
- limited market outlets for chevon and mutton
- inadequate credit facilities, economic incentives, and other support services.

## **Action plan**

- evaluation and promotion of island-born exotic and/or upgraded/indigenous stock of goats (e.g. Dadiangas strain) and sheep
- effective disease control/eradication programmes
- extensive promotion of local sheep production and mutton consumption
- improve marketing/pricing system
- conduct policy studies and advocacy activities.

# **The Philippine cattle industry**

The cattle industry lags behind the other livestock industries. Much of this has to do with the declining trend in cattle population brought about by unabated slaughtering of stocks (about 450,000 head per year) just to meet the increasing demands for beef and beef products

Recently, widespread incidence of diseases, e.g. haemorrhagic septicaemia, tick fever, and FMD have contributed to the decrease in inventory. "Stop-gap" measures of the government have been increased importation of feeder stocks, breeders, and frozen beef products.

## **Inventory**

- decrease trend in inventory from 1.94 million in 1983 to 1.66 million in 1992 (-1.68% per year, average growth rate)
- backyard farms account from 85% of the total inventory; 15% are in commercial farms.

## **Supply and demand situation**

- increase in beef supply from 67,000 t in 1983 to 130,000 t in 1992 (7% per year, average growth rate); a big portion of the supply comes from importation
- increase in beef demand from 52,000 t in 1983 to 102,000 t in 1992 (8% per year, average growth rate)
- average per capita beef consumption increased from 1.00 kg in 1983 to 1.58 kg in 1992.

## **Competitive advantages**

- increasing demand for beef; income elasticity of demand for beef is higher than other meat
- ability to transform low-quality and fibrous feed materials (e.g. grasses and crop residues) into high value protein food product
- abundant supply of crop residues especially in small farms
- favourable climate for fodder production
- cattle production and meat processing technologies are available for increased productivity.

## **Problems**

- low breeding base
- poor nutrition and non-adoption of improved husbandry practices
- seasonal availability of good quality forages
- unavailability of ranching areas including squatter encroachment and land tenure problems

- inefficient marketing system and structure
- inadequate farm to market roads and processing facilities
- inadequate veterinary and extension services.

## **Action plan**

- build up population base through well-defined breeding programme
- increase animal productivity through improved husbandry practices and application of biotechnologies
- promote appropriate feeding using silage technology and encourage utilisation of non-conventional feeds
- strict quarantine procedures and effective disease control/eradication programmes
- improve marketing/pricing system
- review policies on importation and credit system
- develop grades/standards for live animals, carcasses, and other animal products.

# **The Philippine carabao industry**

The carabao industry has yet to achieve its "take-off" stage. Like the cattle sector, the main concern is the declining trend in population brought about by low productivity and high extraction/slaughter rates of the animals.

Increased slaughtering, even of pregnant animals, is carried out to satisfy the ever-increasing demands for beef. To date, the carabao is still the major source of beef sold in the market. In Metro Manila alone, more than half of the beef supply is carabeef (carabao meat).

## **Inventory**

- decreasing trend in inventory from 2.95 million in 1983 to 2.48 million in 1992 (-1.86% per year, average growth rate)
- 99% of total carabao are found in backyard farms.

## **Supply and demand situation**

- increase in carabeef supply from 33,000 t in 1983 to 55,000 t in 1992 (6.51% per year, average growth rate)
- increase in carabeef demand from 28,000 t in 1983 to 47,000 t in 1992 (6.6% per year, average growth rate)
- average annual per capita carabeef consumption increased from 0.54 kg in 1983 to 0.73 kg in 1992.

## **Competitive advantages**

- increasing demand for beef and carabeef
- major source of draft power, milk, meat, and hide
- ability to transform low-quality and fibrous feed material (e.g. grasses and crop residues) into high value protein food product
- abundant supply of crop residues especially in small farms
- favourable climate for fodder production
- carabao production and meat processing technologies are available for increased productivity.

## **Problems**

- low productivity
- poor nutrition and non-adoption of improved breeding and husbandry practices
- seasonal availability of good quality forages
- inefficient marketing system and structure
- spread of diseases and parasites

- inadequate veterinary and extension services.

## **Action plan**

- improve the breeding programme
- promotion and application of appropriate technologies for improved feeding and husbandry practices
- strict quarantine procedures and effective diseases control/eradication programmes
- improve the marketing/pricing system
- develop grades/standards for live animals, carcasses, and other animal products
- review policies and conduct advocacy activities.

## Discussion following Drs Faylon and Roxas's paper

- Vo-Tong Xuan: The report on the Philippine stock production system showed that the production situation seemed to be progressing at a slow rate, especially during 1994. One of the reasons Dr Faylon gave is the feed, especially maize. I read in the newspaper yesterday, that the Philippines is going to import maize again, so this must indicate some problem with the annual production, But what was very impressive were the resources for research.
- Wanapat: This question could be addressed to both the Philippines and Malaysia. I am interested in hearing more on how the government is preparing to develop the manpower in regard to the animal scientists to undertake the upcoming animal science research work. It seems that these research activities in animal science are coming strongly in comparison with other fields.
- Faylon: As I indicated to you, PCCARD is the secretariat. Within our programme manpower development is one element. Specifically our position is that short-term training is not what we need under this particular programme—degree programmes are our concern. For the next two years in relation to our biotechnology programme we see our activities focusing both on the manpower and the infrastructure or equipment requirement of the programme. So, specifically, under our situation—and I think again maybe you have read this in the paper that most of the military bases in Manila were sold to private corporations or the private sector—and the share for science and technology out of the sales will be used on manpower development for science and technology. So in our case that's about 350 million Pesos for the next three years.
- Leng: I want to highlight that one of your programmes was aimed at upgrading copra meal as a feed, presumably for monogastric animals, because this is one of the best supplements we have for ruminants, which, if used effectively, would lift the production of ruminants in this country enormously.
- Faylon: It is very ironic that we have, I think the bulk of copra meal in the same way as molasses, but in many areas where these are produced these two ingredients are not available to livestock because they are exported. Specifically, for copra meal, the economics of the export of this commodity is tremendous to the point that the government feels that if we were able to improve the quality particularly the aflatoxin level, digestibilities etc, then we would be able to get a better price for this. Especially in the last two years feeding of cattle is becoming a viable proposition particularly in the Mindanao area in the south part of the Philippines; copra meal and cassava leaf meal are the major ingredients. We believe it is becoming a good proposition economically under our conditions. But there are several ways in which copra is produced, and particularly those backyard oil meals are producing the inferior quality most of the time. However, this is the source that can serve our local livestock projects as I am sure that more than 90% of that produced by big companies goes to the export market.

- Leng: Copra meal combined with sugar-cane tops are now a well established feeding system that gives 3000 litres of milk when fed at higher than *ad libitum* intake. These techniques are available in the literature, have been proven and can lift levels of production enormously compared with the present levels, if you keep the materials that are needed to supplement animals in the country.
- Faylon: For copra meal there ' is no problem, but lets take sugar-cane tops. In one island in the Philippines we have a lot but the social aspects will always come in. In that particular island they are importing a lot of labour because you know in sugar-cane plantations cane tops are available at harvest time and that is the time where they do not have the labour. Some efforts were made to develop the machines to collect the cane tops, but we still have a very limited success with that. But you know with cane tops, if you fail to conserve or use them within a week, they are essentially fibre. So this is one area where social aspects have a very big part to play in relation to adoption or utilisation of the feed resource.
- Mukherjee: Let me answer the question raised by Dr Metha Wanapat. In regard to manpower development, we have a surplus of livestock scientists at the moment in Malaysia. I think there are more than we require but there is lack of quality. But the new areas where there are job opportunities are, I think, in agriculture and government livestock and environment, ecotourism and the companion sports and recreation sports. The other area I think would be biotechnology, especially in veterinary biotechnology and there will be a lot of jobs available in future. The third area will be livestock and information systems development which will provide but a few jobs. The banking people will utilise some for agribusiness and the livestock business area.
- Fitzhugh: I guess it's fitting to follow on about livestock scientists but the international livestock centre is being encouraged to work more closely with crop centres and to focus more on the farming systems in which there is a crop/livestock activity.
- It occurred to me this afternoon that I had not heard very much about the way that the livestock scientists in the Philippines or in Malaysia or perhaps in the other countries work closely with crop scientists on problems of similar interest. I am just curious as to whether or not this is a common phenomenon; where you are generally working with the plant breeders, with the agronomists and so on, or whether you are rarely doing this?
- Mukherjee: I think that in Malaysia, as I mentioned in my paper, we have to go for integrated production systems. That should be the top priority and that is integrated livestock and crop production systems and the plantation crop production systems mainly. There will be limited area of research in other kind of integrations like the livestock/fish integration including the environmental pollution research, but basically I think the main opportunity will be in the integration of livestock in plantations. And there we have to develop new types of research and training. We have to bring in the training of estate management including the livestock meal management, by-products, even management of the plant-breeding methodologies because we

would like to develop dwarf type plants. In fact the Malaysian oil palm tree is actually an inter-species hybrid. We would like to see the size of the canopy reduced so that the penetration of light increases so that the natural forage can grow under the trees and livestock can obtain more feed. So integration is a very important thing in the future planning of the livestock and tree crop management systems.

Faylon: In the Philippines there are deliberate efforts along that line. But then under field conditions, I think institutionalisation of the scheme is still a long way off.

For example, for at least six years IDRC have supported us on this tree crop/small ruminants system where sociologists, livestock scientists and forest crop agronomists work together. But often I think this structural set up of the various organisations from which these scientists are drawn in many cases causes the problems, each one would really like to highlight what they are doing or what they were able to accomplish. So I think the success of some of the projects using this interdisciplinary agency modality will depend on leadership and institutionalisation of the approach is a bit more difficult. If the team comes from one institution, where they are receiving their instructions and being assessed or their performance is being monitored by a single person, then the success is almost there.

Devendra: There has been very little getting together mainly because the institutional boundaries and rigidities are so very strong. Projects have not allowed for this, and in fact projects have been developed really from external thinking, if I could put it that way, to overcome some of these difficulties.

It is something I feel we need to address very squarely. It relates to project development, it relates to breaking down these very boundaries. If at all we are going to get through to integrated natural resource management it hits at the very heart of project formulation which also Peter Carroll mentioned, and I think this is something we need to come back to stronger discussion in the working groups otherwise we will go back to the old mode of a commodity approach and not really get down to working with the crop scientists.

Vo-Tong Xuan: I think this is really true, because I think this is a process we are going to learn and which we hope to achieve in time. As I mentioned, God created a woman and then he created a man then somehow he made the two married. Then the CGIAR system also created commodity-based centres but then found out the farmers are not dealing with a single commodity, they have to think of how to utilise all the resources. So the CG system thought up the ecoregional approach and now this is what we are doing.

# Research priorities for improving animal agriculture by agro-ecological zone in Indonesia

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## Abstract

The agro-ecological zones (AEZ) in Indonesia are of five categories: wetland, dry land, estate cropland, forest lands, grasslands and other lands. Data are given on the diversity of the animal genetic resources and the size of individual populations. Low animal productivity is apparent for which breed improvement, better feeding and nutrition, and amelioration of the socio-economic conditions of small farmers are the necessary corrective measures. Research issues of strategic importance are livestock and poultry genetic resources, production-oriented research, development, integration of agribusiness, socio-economic studies, appropriate technology development and transfer, research collaboration and networking. These are requirements indicated by AEZ, production systems and animal species. In order to link research and extension closely, institutes for assessment of agricultural technology have been created in 11 provinces.

## Introduction

Currently, Indonesia is embarking on her Second Long-term Development Era (PJP II) and entering the sixth National Five Year Development Phase (Pelita VI). The national economy is expected to move into an industrialisation phase in which the livestock subsector is being considered as a new growth asset. The development of the livestock subsector has received high priority in Pelita VI, and its contribution is projected to reach 6.4% of the Gross Domestic Product. Therefore, new approaches are important for implementation of the plans in order to meet the relatively high contribution anticipated from livestock compared with that of other agricultural commodities.

Many changes have taken place in agricultural policy and organisation, and the focus of attention is now towards resource efficiency, and environmental and sustainable production issues. There is also a major shift in agricultural policy from being production-oriented to income generation, and from a commodity to an agribusiness approach. In view of the ever increasing demand for animal products such as milk, meat, and eggs, there is a tremendous opportunity for further livestock development.

The Agency for Agricultural Research and Development (AARD) has recently committed itself to close the gap between research and extension by taking positive steps in establishing institutes for assessment of agricultural technology (BPTP) in 11 provinces. These institutes are an amalgamation of the former agricultural information centres and sub-research institutes already existing in the provinces.

Research and development efforts to increase livestock production therefore face new pressures in conjunction with the need to produce technologies for further assessment at the BPTPs that are technically sound, economically feasible, socially acceptable and environmentally kind.

In the context of this consultative meeting, the emphasis on agro-ecological zone (AEZ) issues is highly important. It is expected that alternative means to enhance livestock research and development activities could be accommodated in the national planning process.

## **Types of agro-ecological zone (AEZ)**

Indonesia is a large country that consists of over 13,000 islands spread around 5600 km from east to west and 1600 km from north to south. The land area covers 1.8 million km<sup>2</sup>, Of which Kalimantan Island is the largest island covering 28% of total land area. Java island represents only 6–7% of the total land area, however, it is the most densely populated island in terms of both human and animal populations.

Geologically, Indonesia lies within two relatively stable blocks—the Sunda shelf in the west and the Sakul shelf in the East—between which lies a highly unstable block composed of deep basins alternating with blocks that rise above sea level to form islands. Each island consists of highlands, high plains of thin alluvium and low plains of deep alluvium on the coastal areas.

Soil fertility is strongly affected by climate: heavy rainfall leads to soil erosion and high temperatures lead to rapid chemical weathering. These characteristics help determine the cropping pattern applied. Soil in the eastern part of Indonesia is generally too poor to be able to support intensive cropping without addition of fertilisers.

The temperature in Indonesia, being a tropical country, stays within constant ranges, differing only a few degrees between hot and cool months: 23–31°C daily in the low plains and 18–27°C in the interior plateau. Rainfall, however, varies in terms of distribution and amount and the agricultural systems are regulated more by rainfall than temperature.

The climate is influenced by monsoons, in a pattern which varies depending upon the location of the Indonesian island from the equator. The West Monsoon brings rain to South Sumatra, Java and the Nusa Tenggara Islands (Lombok, Sumbawa, Sumba and Timor). In contrast the East Monsoon brings dry air from Australia. In East Java and the Nusa Tenggara Islands there is a significant difference between the wet and dry season.

Indonesia can be divided into various types of agro-ecological zone:

1. Wetlands in which rice is the predominant crop. These are found in the western part of Indonesia which includes Java, parts of Sumatra and Kalimantan, South Sulawesi and Bali.
2. Dry lands which include parts of watershed areas in Java, the Nusa Tenggara Islands and Sulawesi. In the Nusa Tenggara Islands, large plains of savannah exist naturally, whereas in South Sulawesi natural grasslands/pastures can be found.
3. Estate cropland, which ranges from sea level to 1000 m asl, are found in Sumatra and Kalimantan. These areas support plantation crops such as rubber, oil palm, coffee, tea etc.
4. Forest lands which comprise a large part of Sumatra, Kalimantan and Irian Jaya. In Java, Bali and Madura, and to some extent in Sulawesi, forest land comprise only a small proportion of the land area.

5. Grasslands which exceed the wetlands in area, although they are proportionally smaller than the forest land, are found in the Nusa Tenggara Islands and Sulawesi.
6. Other lands which include land classes such as waste land, denuded areas, freshwater and coastal swamps and tidelands.

## **Animal production systems**

The majority of livestock and poultry are kept in smallholder systems. These are an integral part of the cropping systems in which land ownership is small (0.25 ha). Cropping covers approximately 29 million hectares of the 130 million hectares of arable land available. About 9 million hectares are dry land and 8 million are wetlands, including rainfed land suitable for rice cultivation; about 7 million hectares are planted with perennial crops. Secondary crops including maize, cassava, peanuts, soybeans etc cover more than 5 million hectares. Food crops dominate the agricultural sector and their by-products support livestock production as feed, in particular in the inner islands and transmigration areas. The intensity of land use is high with rice–rice or rice–secondary crop farming being almost continuous systems.

The majority of livestock are raised on wet and dry lands and 70–80% of the total livestock population are raised in Java under traditional systems. Under these systems, a very small number of animals (2–3 head/farm) are kept in a subsistence-oriented production system that gains less than 30% of gross farm product from the livestock. This type of system has dominated the production of livestock in most regions. To improve the present animal production conditions, the national policy is to develop systems under a partnership relationship between the smallholder and the strong commercial enterprises as the centre of production. The centres provide capital and technology, and ensure the marketing of products.

In the eastern part of Indonesia, there are open grasslands for grazing cattle and goats under a continues grazing management system. The grazing lands are communal and anyone can graze their animals there. The number of animals per farm (20–50 head/farm) is larger than that of the subsistence system. Feed shortage is a major problem, especially in the dry season, during which time animals lose weight. The major market for live animals is Jakarta, placing importance on transport facilities for live animals.

In Sumatra there are several thousands of hectares of large plantations growing rubber and oil palm trees. These have, over the years, been free from animals because they have been regarded as pests. The results of research efforts conducted at Sei Putih to develop an integrated sheep and rubber production system has created a growing interest in producing sheep under rubber and oil palm plantations.

## **Animal resources**

The agricultural resource potential of Indonesia is very large and apparently not optimally utilised. There is often over-utilisation of natural resources in densely populated areas and under-utilisation in the scarcely populated areas. Indonesia is known for her rich germplasm resources of both plant and animal species, most of which are beyond the current research capacity to utilise and manage; some are in the category of endangered species. There are a number of indigenous breeds

available in Indonesia that are generally small and slow growing, hence the interest to improve their genetic quality.

There are a number of enviable gene pools of adapted livestock that have not been fully exploited in terms of growth rate or reproduction. The important indigenous breeds of farm animal in Indonesia (see Table 1) are raised under traditional management systems with low input. The commercial enterprises have not relied on indigenous breeds as these are considered of low productivity. Furthermore, there is no guarantee of obtaining a regular large supply of animals. However, there is a growing interest in taking advantage of the genetic superiority of the indigenous breeds.

**Table 1.** *Indigenous animal breeds available in Indonesia.*

| Animal species  | Breeds available     | Agro-ecozone    | Location               |
|-----------------|----------------------|-----------------|------------------------|
| Large ruminants | Sumba Ongole         | Dry land        | Sumba Island           |
|                 | Ongole cross (PO)    | Dry and wetland | East Java              |
|                 | Bali cattle          | Dry and wetland | Bali, Sulawesi, NTT    |
|                 | Madura cattle        | Dry and wetland | Madura                 |
|                 | Aceh cattle          | Dry and wetland | D.I. Aceh              |
|                 | Pesisir cattle       | Dry land        | West Sumatra           |
|                 | Grati cattle         | Dry land        | East Java              |
|                 | Swamp buffalo        | Wetland         | Java                   |
|                 | Murrah buffalo       | Dry land        | West and North Sumatra |
|                 | Toraja buffalo       | Dry land        | Sulawesi               |
|                 | Kalang buffalo       | Wetland         | South Kalimantan       |
| Small ruminants | Javanese Thin-tailed | Dry land        | Java                   |
|                 | Javanese Fat-tailed  | Dry land        | East Java              |
|                 | Kacang goat          | Dry land        | S. Sumatra, W. Java    |
|                 | Etawah cross goat    | Dry land        | Java, Sulawesi         |
|                 | Gembrong goat        | Dry land        | Central Java           |
|                 | Kosta goat           | Dry land        | West Java              |
| Chickens        | Kampung chicken      | Dry and wetland | Indonesia              |
|                 | Kedu chicken         | Dry and wetland | Central Java           |
|                 | Pelung chicken       | Dry and wetland | Central Java           |
|                 | Bekisar              | Dry and wetland | East Java              |
|                 | Nunukan              | Dry and wetland | West Java              |
| Ducks           | Tegal duck           | Wetland         | Central Java           |
|                 | Modjosari duck       | Wetland         | East Java              |
|                 | Alabio duck          | Wetland         | Kalimantan             |
|                 | Bali duck            | Wetland         | Bali                   |
| Swine           | Java pig             | Dry land        | Java                   |
|                 | Bali pig             | Dry land        | Bali                   |
|                 | Nias pig             | Dry land        | Nias, N. Sumatra       |

Of the large ruminant breeds, the Ongole cattle fall into two categories: Sumba Ongole which was imported from India in the early 1890s to the island of Sumba

and has been kept as pure bred *Bos indicus* ever since. The Peranakan Ongole (Ongole cross with native breeds) are found in Java. Bali cattle are believed to be the result of domestication for centuries of the wild banteng, classified as *Bibos sundaicus*. The Bali cattle have a reddish coat with a typical white colour on the hindquarters stretching along the belly and legs running from the hoof to just above the hock. The male hair coat turns black when the animal reaches puberty.

The Madura cattle appear to be a cross between the Bali cattle and indigenous cattle in Madura Island. These animals are small and have been raised on the island of Madura for "karapan" purposes. The Aceh are a small breed of cattle found in the special district of Aceh. This breed has the potential to be exploited as one that is resistant to high temperatures. Relatively little is known about the Pesisir cattle found in the coastal area of West Sumatra.

Dairy cattle are found in dairy centres and are mostly descendants of the Friesian-Holstein (FH) introduced by the Dutch in the early 1900s. The present strategy to improve the dairy production through genetic means is by importation of proven semen for artificial insemination (AI) purposes, and also live Holstein-Friesian cows and bulls from various parts in the world. The Grati cattle are regarded as indigenous, being a cross between the Friesian and local breeds over centuries. They are mainly raised in Grati, East Java, for milking purposes and have become adapted to the hot dry environment.

Swamp buffaloes can be found in the wet areas and are generally used for draft power in ploughing rice fields. The Murrah buffalo (riverine buffalo) is a milking type buffalo found in North and West Sumatra. There have been limited efforts to improve the genetic quality and productivity of buffaloes. An interesting indigenous buffalo breed is the Toraja buffalo, which is distinct from the above breeds, having a spotted coat colour. Not much is known about the genetic quality of this breed as they have been raised for special purposes only in Toraja, Sulawesi. The spotted coloured buffalo does not necessarily descend from spotted coloured buffalo parents, and mating of spotted coloured buffalo cows and bulls does not produce spotted coloured offspring. The Kalang buffalo are found in South Kalimantan and are raised in herds of 50–60 head. These animals are well adapted to swamp and tidal areas and can take advantage of the underwater biomass.

The majority of the small ruminants are raised in smallholder farms (3–4 head/farm) on the island of Java. The most important sheep breeds available are the Javanese Thin-tailed, the majority of which are found in West Java, and Javanese Fat-tailed of East Java. These sheep breeds have coarse wool and about 17% of the Javanese Fat-tailed sheep population have hair type coats. It was thought that the hair type sheep may have some advantages to cope with the hot humid tropical environment. The indigenous sheep breeds are prolific animals (average litter size of 2.8 under good management) and their contribution is very significant in the present farming systems. They are generally small, however, there is a wide variation in the population making the possibility of selection within breeds very promising. Of the existing goat breeds, the Kacang goat (Kambing Kacang) and the Peranakan Etawah (Etawah cross goat) are found throughout Indonesia. The Etawah cross is a cross between the Jamnapari from India (introduced over a century ago) and the Kacang goat, aimed at improving the milk production and size of the animals. The population of goats is double that of sheep, however, not much research work has been carried out on goats. While the pure Kacang and Etawah goats are diminishing, they can still be found in a few isolated areas. Other miscellaneous goat breeds are the Gembrong and the Kosta. The performance of

these goats is different from that of the Kacang and Etawah cross, however, they may well be their crosses with other introduced breeds like the Saanen and Toggenburg.

The majority of indigenous chickens of Indonesia are nondescript breeds. They are believed to be descendants of the jungle fowl and are called the Kampung chicken (Ayam kampung). The red jungle fowl can still be found in isolated areas. There are also a few distinct breeds of chicken, namely the Kedu, Pelung and Bekisar that have been raised for special purposes in small numbers. There is an increasing interest in the genetic quality of the native chicken since they are well adapted to the traditional management systems. Resistance to certain diseases is one of their superior characteristics over the hybrid chicken breeds being imported from Australia, Europe and the United States.

The major indigenous duck breeds are found in Java and Kalimantan. They are mainly raised in irrigated rice areas under scavenging systems at harvest time. The important duck breeds are the Tegal duck in Central Java, Mojosari duck in East Java, Alabio duck in Kalimantan and Bali duck in Bali. It has been reported that the improved duck breed, the Khaki Campbell, was developed in England from the Tegal breed and others. The primary product from duck production are eggs which are sold fresh, salted or as fertilised eggs for hatching purposes. The production of duck meat is growing due to increasing demand. The Bali duck found in Bali Island have a plume on the head which is peculiar.

Pigs, like other farm animals, are a source of income for the non-Moslem smallholders and for small and large specialised commercial swine producers. There are three recognised breeds of swine. The Java pig is considered a cross between the European breed boars and indigenous sows, and these are found in Java. The Bali pig is of the Chinese type with black colour and white skin with many folds. The Nias pig is believed to derive from East Indian pigs and is related to feral pigs with black hair and short ears.

## **Animal populations**

The farm-animal population by species and year is given in Table 2. The data indicate that the livestock population is increasing each year, but live animals (cattle and sheep) for slaughter are at present being brought in from Australia to meet the demand for good quality meat. In general, the farm animals are kept by smallholder farmers under traditional management systems with a farm scale of 2–3 animals/farm. Land holdings are relatively small, averaging only around 0.25 ha, which limits the use of heavy machinery. However, draft animal power, although popular with smallholders, is becoming scarce. Animals are kept by farmers as living savings account to accumulate wealth, as sources of fertiliser and users of crop by-products. This type of production system has supported the production of meat and other animal products for ages and probably will remain, unless new approaches are implemented. Perhaps the most remarkable success is the development of specialised commercial poultry operations; large-scale enterprises are at present contributing around 30% of the country's poultry meat production.

**Table 2.** *Livestock and poultry population (million head).*

| Year | Beef cattle | Dairy cattle | Goats | Sheep | Swine | Village chicken | Layers | Broilers |
|------|-------------|--------------|-------|-------|-------|-----------------|--------|----------|
| 1985 | 9.32        | 0.21         | 10.63 | 4.89  | 5.56  | 156             | 32     | 144      |
| 1986 | 9.43        | 0.22         | 10.74 | 5.28  | 6.22  | 163             | 39     | 174      |
| 1987 | 9.51        | 0.23         | 10.39 | 5.36  | 6.34  | 168             | 40     | 218      |
| 1988 | 9.78        | 0.24         | 10.61 | 5.83  | 6.48  | 183             | 38     | 227      |
| 1989 | 10.09       | 0.24         | 10.99 | 5.91  | 6.94  | 191             | 40     | 262      |
| 1990 | 10.40       | 0.25         | 11.00 | 6.00  | 7.40  | 200             | 44     | 285      |
| 1991 | 10.70       | 0.25         | 11.44 | 6.05  | 7.90  | 208             | 45     | 350      |
| 1992 | 11.00       | 0.28         | 11.75 | 6.10  | 8.00  | 210             | 47     | 420      |
| 1993 | 11.30       | 0.28         | 11.75 | 6.15  | 8.01  | 211             | 49     | 425      |

Source: Anonymous (1993).

The promotion of dairy and beef production is currently receiving considerable emphasis. Dairy co-operatives are being developed to take responsibility for meeting milk demand and reducing milk importation. Feedlot projects have taken off in the last few years and range from 6–10,000 head per unit. The problem faced by the feedlots is the availability of feeder cattle which is at present met by importation of live animals from Australia and New Zealand for fattening and slaughter. It is apparent that the demand for beef will continue to rise due to improved living standards of the people as a result of success in development efforts and population growth.

## Constraints to production

The major concern with development of the livestock sector is the low productivity of the indigenous breeds in Indonesia. Breed improvement schemes based on village production systems are not presently available. In the dairy business, Friesian-Holstein semen and live animals from Australia, New Zealand and the USA have been imported to increase milk production. To close the widening gap between demand and supply of beef, the importation of live feeder cattle for fattening has been opened on a limited basis. The success in poultry production relies heavily upon the use of introduced chicken breeds since these are raised under intensive production systems.

The main approach to improve the indigenous breeds was through cross breeding the local indigenous breeds with improved breeds. It is unfortunate that most of the improved breeds have been developed in temperate regions, which limits their adaptability and capacity to express their superiority when raised in tropical environments. In addition, this approach is also limited by the present poor management conditions at village level. The introduced, improved breeds may not express their full genetic potential, hence, their performance does not exceed that of the locally available breeds. It is believed that selection within existing breeds may have more advantages, applying an open nucleus breeding scheme in village breeding centres.

Feeding and nutrition to provide sufficient amounts of quality feeds for the animals to ensure production is always a concern. It depends heavily upon farmers capacity to find feeds from what is available in the immediate vicinity. Additional inputs for

better feeding are generally beyond the farmers economic capacity, except for dairy farmers. Feeding of ruminants is heavily dependent on agricultural by-products at harvest time and the use of native grasses that grow naturally on public lands. The use of concentrates as supplement is limited, particularly for beef, mutton and goat meat production. While the smallholder farmers do not produce their own roughage feed, the supply of roughage for dairy cattle is specially grown by some commercial dairy farmers. The medium and large poultry enterprises are supported by large feed mills that produce commercial concentrate feeds. Many of the feed ingredients have to be imported while some are produced locally. The use of feed additives in commercial poultry farms is not uncommon.

The socio-economic condition of farmers is a major constraint to improved production of animals under village conditions. The approach being taken is to link the commercially better-off business farmers with smallholders in a partnership operation. The commercial farms provide the necessary inputs and assist in the marketing of products. Transfer of technology is anticipated to take effect through such linkages.

## **Researchable issues**

Development policy is directed at sustaining what has been achieved and has been expanded to address new strategic issues.

The national agricultural policy can be grouped into three major categories.

1. Sustainable agriculture and resource management which includes efficient utilisation of biophysical resources, facilities and infrastructure, and the utilisation of sustainable measures, human resource development and science and technology that support location-specific research and development, and facilitate technology transfer.
2. Operational development policy includes food self sufficiency, links smallholder farms in an integrated approach to large commercial enterprises, poverty alleviation, development of investment, trade and export, and seeks to establish rurally-based industries in an agribusiness approach.
3. Institutional development which includes strengthening of administrative and management systems, intersectoral co-ordination and regional and international co-operation and collaboration.

The research issues of strategic importance are as follows:

1. Research on livestock and poultry genetic resources and including inventorisation, characterisation, utilisation and conservation. The research efforts should be able to (a) determine the potential of existing genetic resources, (b) offer alternatives for sustainable utilisation and management of resources within the overall scheme of their spatial and regional allocation and (c) evaluate, characterise, utilise and conserve/preserve the existing germplasm resources.

A promising breakthrough is anticipated to emerge for poultry and small ruminant production, since these animals are closely related to the farm activities. Genomic mapping of the prolificacy trait in the Javanese Thin-tailed sheep has been initiated in collaboration with CSIRO, Australia. Similar techniques will be used to utilise the genetic potential that exists in indigenous breeds to enhance the selection of superior individuals from the population.

The development of an open nucleus breeding scheme is also being tested with native chicken, ducks, Javanese Fat-tailed sheep and Etawah cross goats.

2. Production-oriented research includes promotion of the genetic potential of livestock and poultry resources for higher production, productivity, employment, income and equity. The research policy is to continuously improve the production and productivity of livestock and poultry through efficient and environmentally friendly technology towards sustainable agricultural development.

This includes the development of better feeding through intensive utilisation of agricultural and industrial by-products and shrub legumes. Many potential agricultural and industrial by-products exist, e.g. coffee and cacao by-products, pineapple waste etc. The potential of *Gliricidia sepium* and *Calliandra calothyrsus* is being assessed, including feed processing techniques to overcome the limitations of anti-nutrient factors. To increase feed utilisation of ruminant animals, manipulation of the rumen fermentation process is being exercised through utilisation of selected rumen microbial species, and supplementation with feed additives (enzymes, micro-minerals etc) to enhance fibre digestion in the rumen. The development of protein enrichment techniques for naturally carbohydrate rich materials, as substitutes for protein-rich ingredients that are generally expensive, have yielded promising results with cassava products. Research is underway to apply the techniques to sago products and wastes.

3. Development of appropriate technologies through "on farm research" to provide breakthroughs in creating farming system alternatives that are (a) economically feasible (input efficient and competitive), (b) socially acceptable for better health and nutritional status, and (c) environmentally sustainable.

The present trend is the development of integrated production systems involving animals and food crops, ruminants and estate crops (rubber, oil palm, coconut and coffee), poultry and fisheries, in view of the large potential to utilise the land under these trees more efficiently. To improve smallholder systems, various production schemes are being tested in which farmers are expected to produce based on an agreed target set at the start of the programme.

4. Research on integrated agribusiness offers alternatives to stimulating improvement in farming systems and agro-industries, for an efficient and dynamic rural economy, along with optimum and sustainable utilisation of livestock and poultry resources in the region.

In collaboration with the private sector, new approaches are developed and tested aimed at establishing an industry that benefits farmers and the private enterprise.

5. Socio-economic studies to analyse systematically and periodically the livestock and poultry industries to provide direction for commodity development, alternative policies for rural socio-economic development, institution building, and development models for the national and regional livestock and poultry development.
6. Technology transfer, research collaboration, and networking to encourage and accelerate the process of acquisition, utilisation and development of location specific livestock and poultry industries. The establishment of "assessment

institutes or BPTPs" in each province demands a rapid flow of information to cope with the newly emerging problems in the dissemination of new technology. A harmonious research extension linkage is anticipated to close the gap between research and extension experienced in the past.

Table 3 presents researchable issues to improve livestock and poultry production in Indonesia described to overcome constraints in various AEZs.

**Table 3.** *Animal species, researchable issues relating to agro-ecozoning.*

| Agro-ecozone           | Geographical zone                                                    | Production systems               | Animal species                  | Research issues                                                                                                                                                                                 |
|------------------------|----------------------------------------------------------------------|----------------------------------|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Wetland                | Java, Sumatra, Bali                                                  | Subsistence<br>Small scale       | Livestock and poultry           | Breed improvement, rice by-product utilisation, tree and shrub legumes, feed technology, disease, crop-animal production systems, livestock-based industry development, post-harvest technology |
| Dry land/<br>semi-arid | Java, Sumatra, Kalimantan, Nusa Tenggara, Maluku, Irian Jaya, Timtim | Subsistence<br>Commercial        | Cattle, sheep, goat and chicken | Breed improvement, crop by-product utilisation, shrub legumes, feed technology, rumen manipulation, disease, crop-animal production systems, socio-economic studies, post-harvest technology    |
| Grassland              | Nusa Tenggara, Sulawesi, Aceh, N. Sumatra                            | Extensive grazing                | Cattle, goats, buffalo          | Grazing management, pasture improvement, eradication of alang-alang, transport and marketing, breed improvement, social studies                                                                 |
| Estate cropland        | Sumatra, Kalimantan, Sulawesi                                        | Commercial<br>Medium-large scale | Cattle, sheep                   | Forage production, estate crop by-product utilisation, integrated production systems, shade tolerant forage, disease, grazing management                                                        |
| Forest land            | Sumatra, Kalimantan and Irian Jaya                                   | Subsistence                      | Environmental issues            | Buffering zone establishment                                                                                                                                                                    |
| Others                 | Sumatra, Kalimantan and Irian Jaya                                   | Subsistence                      | Buffalo, ducks                  | ?                                                                                                                                                                                               |

### National research capacity

The Research Institute for Animal Production (RIAP) in Ciawi-Bogor has a national mandate to develop technologies in livestock and poultry husbandry, whereas the Research Institute for Animal Disease (RIAD) is concerned with animal disease problems in general. With the recent change in organisational structure, RIAP and RIAD are the only research institutes under the Central Research Institute for Animal Science (CRIAS) of AARD that carry out basic research in animal production and disease. Research is also carried out by scientists at universities in conjunction with educational training. The BPTPs at the provincial level have the mandate to assess the technologies developed by RIAP

and RIAD that are locally specific and promising for implementation in the region. Through close collaboration between researchers and extensionists more could be gained from the direct feedback obtained.

Research activities at RIAP and RIAD are concerned with various aspects that affect the production of livestock (cattle, buffalo, sheep and goats) and poultry (chicken, quails and ducks) including breeding, genetics, reproduction, feeding and nutrition, feed technology, socio-economics and post-harvest technology. The research facilities available include animal barns, laboratory equipment, library, information etc. They are considered among the best in SE Asia. In terms of manpower, RIAP and RIAD have a number of well trained researchers at the PhD level in different fields (Table 4). The majority of these individual have been trained overseas.

**Table 4.** *Research staff at RIAP and RIAD.*

| Type                    | RIAP |     |        | RIAD |     |        | RIAP+RIAD |     |
|-------------------------|------|-----|--------|------|-----|--------|-----------|-----|
|                         | PhD  | MSc | Others | PhD  | MSc | Others | Total     | %   |
| Ruminants               | 18   | 25  | 16     | 4    | 13  | 13     | 23        | 99  |
| Non-ruminants           | 11   | 12  | 8      | 5    | 9   | 8      | 62        | 19  |
| Forage, feed technology | 10   | 10  | 14     | 0    | 0   | 0      | 34        | 10  |
| Others                  | 8    | 18  | 83     | 0    | 0   | 3      | 112       | 34  |
| Veterinary discipline   | 1    | 0   | 4      | 2    | 3   | 10     | 19        | 6   |
| Total                   | 48   | 65  | 132    | 11   | 25  | 44     | 326       | 100 |

### Existing international programmes

Over the years many collaborative research programmes with international involvement have been carried out. In the early 1970s the Australian government, through the Commonwealth Scientific Industrial Research Organisation (CSIRO), supported the establishment of the research institute at Ciawi. Collaborative research activities with international donor agencies and private companies include studies on genetic improvement of the fat-tailed sheep with the Food and the Agricultural Organization of the United Nations (FAO), nutrition studies to improve the productivity of Sumba Ongole cattle with the Australian Centre for International Agriculture Research (ACIAR), research on diseases including diagnosis and control of haemorrhagic septicaemia, the evaluation of antigens for vaccination against liver fluke in cattle and buffalo, control of fascioliasis (*Fasciola gigantica*) in cattle and buffalo, with CSIRO on genomic mapping of prolificacy in Javanese Thin-tailed sheep, and with USAID on production aspects of small ruminants. The International Development Research Centre (IDRC) has played a major role in the establishment of the Small Ruminant Production Systems Network for Asia (SRUPNA), and the University of Edinburgh for research on anti-nutrients in *Calliandra calothyrsus* etc. Various other international agencies are also involved in research and development of other commodities.

In this globalisation era, research collaboration will have to be enhanced to obtain greater impact from livestock research to counter the increasing production and sustainability problems that will be encountered in the future.

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## **Discussion following Drs Djajanegara and Diwyanto's paper**

Qureshi: I should congratulate the speakers on the comprehensive papers which were interesting and reflect the national research plans. Like all national plans, they include everything. And there is a logic to it, yes but, what are the priority areas?

Djajanegara: The priorities are different depending upon your focus. But, if I have to pick out the policy of the Indonesian Government which we are trying to develop, it would be the eastern part of Indonesia. In this part of Indonesia, the most important system is beef production. Breed improvement comes first for the dry area and then the crop by-product utilisation and then legumes.

# Research priorities for improving animal agriculture by agro-ecological zone in Thailand

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## Abstract

Thailand, a country situated in the heart of the Indo-china Peninsula, covers a total area of 518,000 km<sup>2</sup> and has a population of about 60 million people. Despite the country's rapid development and increased GNP of 8% per annum, the majority of people (80%) still reside in rural areas and engage in agriculture. Under the prevailing conditions, and considering the available farm holding area together with high land prices, any increase in agricultural production is envisaged to come per land unit used or per livestock unit raised. Under the 8th National Economic and Social Development Plan (1997–2001), livestock production aims to increase farmers income and improve their standard of living. The national policy emphasises an increase of dairy and beef cattle by 10,000 and 50,000 head per year, respectively, and to increase buffalo production for meat in addition to draft power. Commercialisation of swine and poultry production has been established and the products exported—particularly those from chickens. Within this farming context, several production systems, animal species and research disciplines need to be developed and pursued. Priority has been given to large ruminants (dairy and beef cattle, and buffalo), small ruminants (goats and sheep) and non-ruminants (swine and poultry). Dairy, beef and buffalo grass/crop residue-based production systems are being promoted in the north-east and north. Goats and sheep in rubber and coconut plantation-based production are prominent in the southern region and commercial swine and poultry production are found in the central regions. Livestock research should focus on strategic utilisation of locally available crop residues, by-products and forages (rice straw, sugar-cane tops, cassava waste, cottonseed meal, *B. decumbens*, *B. ruziensis* etc). Improvement strategies would include strategic supplementation with high quality feed blocks (HQFB) for producing dairy and beef cattle year-round feeding systems. Animal physiology and genetic parameters for study would include factors affecting low reproductive efficiency, improvement of locally available gene resources and cross-breeding programmes, improvement of artificial insemination services, and related enhanced biotechnologies. Research is also required on health aspects such as improved control of zoonotic diseases and efficient means of vaccine production, parasite transmission and their efficient eradication, and technology improvement. Research should extend from basic and applied research to on-farm research and development trials. There is also a need to establish a critical mass of researchers in the future, to increase their research efficiency and thus strengthen global collaboration.

## Introduction

### Geographical and general characteristics of Thailand

Thailand, a golden axe country, is situated between latitudes 6 and 20°N and between longitudes 93 and 106°E. It is bounded by the Socialist Republic of the Union of Burma (Myanmar) and the Democratic People's Republic of Laos in the

north, Myanmar in the west, Democratic Kampuchea and the Democratic People’s Republic of Laos in the east and Malaysia in the south. The country covers an area of about 518,000 km and is divided into 73 provinces. The maximum distance from north to south is about 1650 km and that from east to west is 800 km.

Thailand is divided into four geographical regions. The northern region is mountainous with fertile valleys and plains suitable for growing cash crops and for forestry. The north-eastern region is a plateau: its long dry season, soil with low organic matter and low water-holding capacity, and relatively scarce rainfall make it the least productive region in the country. The central region is located in the fertile Chao Phaya River basin. It is one of the richest rice fields in the world. The southern region is rich in natural resources such as tin, rubber. tropical crops and fisheries. Thailand's present population is about 60 million people about 80% of whom still live in rural areas and engage in agriculture. Buddhism has long been the religion of the majority of Thai people (more than 95%). Art, literature, education and even the social system are pervaded by Buddhism. The culture of the rural people consists of three concepts: spiritual life, village-centred life and family life.

Thailand has a total land area of 321.25 million rai (about 51 million hectares) of which 26.6% is forest land and 41.5% is farm holdings. Paddy land accounts for over 60% of the farm land. The most fertile land is in the Chao Phya River basin. Irrigated land accounts for only 15% of total area, the rest being rainfed.

Thailand has a monsoon-type, tropical climate influenced by three major air streams of different characteristics, namely the south-west, north-east and southerly winds. In addition, cyclonic rain and cyclones can influence the prevailing weather. Normally the country can be roughly divided into two parts according to the weather, namely the continental mainland and the peninsular region. Detailed geographical characteristics are given in Table 1 while Figure 1 is the map of Thailand (APCTT 1986; Chandrangu and Archalaka 1985).

**Table 1.** Summary of various characteristics by region.

| Region           | Province no. | Location    | Rainfall (mm/yr) | Soil type                                             |
|------------------|--------------|-------------|------------------|-------------------------------------------------------|
| A. North-eastern | 17           | lat 14–19°N | 1000             | Sandy, low organic matter, low water-holding capacity |
| B. Northern      | 17           | lat 15–20°N | 1500             | Alluvial to clay loam                                 |
| C. Central       | 25           | lat 13–15°N | 1300             | Alluvial soils                                        |
| D. Southern      | 14           | lat 06–11°N | 2100–4725        | Clay–sandy loam                                       |

**Figure 1.** Map of Thailand.

### Agro-climatic and agro-ecological classification

The amount and pattern of rainfall in Thailand varies significantly in the different geographical areas. The agroclimatic classification based on rainfall in Thailand has been proposed to identify dry and wet months of the year. Rainfall below 100 mm is classified as a dry month and above 200 mm is wet month. A total of 10 agroclimatic zones have been reported (Figure 2) (Chandrangu and Archalaka

1995 .) As illustrated, large areas, especially those located in the north and north-east, have a long dry season exceeding six months. The long dry season in these regions has exacerbated the low productivity of crop and livestock performances. The agro-ecological zone of the north-east has been illustrated by Craig and Pisone (1985): the hill system, mini-watershed system, irrigation system, non-flood plain system and the flood-plain system. These systems could be used in determining relevant crop–livestock production in order to increase efficiency.

**Figure 2.** *Agroclimatic classification.*

**Land classification and uses**

The total land area of Thailand is 51,311 x 10<sup>3</sup> hectares. Distribution by regions is illustrated in Table 2. The northern and north-eastern regions are the two largest regions. Distribution and the uses of farm land are given in Tables 2 and 3.

**Table 2.** *Land classification of Thailand (x 10<sup>3</sup> ha).*

| Region               | Forest | Farm holding | Unclassified | Total  |
|----------------------|--------|--------------|--------------|--------|
| North-eastern        | 2180   | 9235         | 5471         | 16,855 |
| Northern             | 7714   | 4703         | 4547         | 16,964 |
| Central              | 2431   | 4581         | 3379         | 10,390 |
| Southern             | 1345   | 2773         | 2953         | 7071   |
| Total                | 13,670 | 21,292       | 16,349       | 51,311 |
| % of total land area | 26.6   | 41.5         | 41.5         |        |

Source: Center for Agricultural Statistics (1993).

**Table 3.** *Distribution and uses of farm-holding land (x 10<sup>4</sup> ha).*

| Region                 | Housing | Paddy field | Field crop | Fruit and tree crops | Vegetables and flowers | Livestock grazing | Idle  | Others | Total  |
|------------------------|---------|-------------|------------|----------------------|------------------------|-------------------|-------|--------|--------|
| North-eastern          | 20.04   | 607.56      | 215.27     | 29.50                | 3.34                   | 6.31              | 33.10 | 8.34   | 923.49 |
| Northern               | 15.08   | 243.15      | 167.60     | 28.06                | 4.40                   | 2.14              | 6.91  | 2.95   | 470.31 |
| Central                | 13.64   | 200.49      | 151.01     | 70.07                | 4.90                   | 1.99              | 7.12  | 8.79   | 458.07 |
| Southern               | 7.82    | 57.80       | 2.40       | 193.93               | 1.20                   | 0.85              | 10.81 | 2.69   | 277.34 |
| Total                  | 56.58   | 1109.0      | 536.30     | 321.57               | 13.73                  | 11.37             | 57.94 | 22.77  | 229.2  |
| Per cent of total land | 2.7     | 52.1        | 25.2       | 15.1                 | 0.6                    | 0.5               | 2.7   | 1.1    |        |

Source: Center for Agricultural Statistics (1993).

A large portion of land is used for rice, field crops, and fruit tree plantations in all regions. Livestock grazing areas are also available in all regions, however, they only account for a small portion of the total farm area. It also should be noted that areas of idle land are available in large quantity. The characteristics of farm-holding land are presented in Table 4. Land used for farming either belongs to the farmers or is rented from others (73.4 and 26.6%, respectively). Within the farmer-owned land, about 12% has been mortgaged out. Based on the above

statistics and with the present high price of land, the possibility of expansion of land use for agriculture is very limited. The strategy is therefore to increase the efficient use of available resources in order to increase the production per unit of land used.

**Table 4.** *Characteristics of farm-holding land ( $\times 10^6$  ha).*

| Region        | Owned |               |                  | Others |              |      |                 |
|---------------|-------|---------------|------------------|--------|--------------|------|-----------------|
|               | Owner | Mortgaged out | Total            | Rent   | Mortgaged in | Free | Total           |
| North-eastern | 7.29  | 0.78          | 8.07             | 0.48   | 1.04         | 0.57 | 2.09            |
| Northern      | 2.84  | 0.63          | 3.47             | 0.83   | 0.14         | 0.38 | 1.35            |
| Central       | 2.71  | 0.49          | 3.20             | 1.16   | 0.01         | 0.22 | 1.39            |
| Southern      | 2.36  | 0.17          | 2.43             | 0.09   | 0.12         | 0.13 | 0.34            |
| Total         | 15.21 | 2.17          | 17.28<br>(73.4%) | 2.56   | 1.41         | 1.30 | 2.27<br>(26.6%) |

Source: Center for Agricultural Statistics (1993).

## Livestock population and production systems

The livestock population for 1993 has been compiled by the Center for Agricultural Statistics and FAO/RAPA (1994) and is presented in Table 5. Under the prevailing conditions and production systems, the populations of beef and dairy cattle are anticipated to increase to boost production and to provide for larger domestic demand. The optimum production levels for swine and poultry have been reached recently and the rate of increase in population is anticipated to be minimal.

**Table 5.** *Livestock population distributed in various regions of Thailand (head  $\times 10^6$ ).*

| Region        | Cattle | Buffalo | Goat <sup>1</sup> | Sheep <sup>1</sup> | Swine | Poultry <sup>2</sup> |
|---------------|--------|---------|-------------------|--------------------|-------|----------------------|
| North-eastern | 2.098  | 3.697   |                   |                    | 1.178 | 39.089               |
| Northern      | 1.370  | 0.747   |                   |                    | 1.243 | 30.095               |
| Central       | 1.380  | 0.362   |                   |                    | 1.487 | 39.796               |
| Southern      | 0.967  | 0.155   |                   |                    | 0.747 | 15.982               |
| Total         | 5.815  | 4.862   | 0.160             | 0.176              | 4.655 | 124.96               |

1. Goats and sheep are mainly raised in the south.

2. Poultry (chicken + ducks).

Sources: Center for Agricultural Statistics (1993), FAO/RAPA (1994).

Livestock production in Thailand plays a crucial role which extends beyond the traditional uses of supplying only meat and milk. Livestock are used for multiple purposes such as draft power, a means of transportation, capital, credit, meat, milk, social value, by-product uses, hides and as a source of organic fertiliser for seasonal cropping. Livestock have a significant capacity to utilise on-farm resources, especially the agricultural crop residues and by-products which are abundantly available. Livestock/crop holdings have been in the hands of the rural resource-poor farmers for many decades and it is likely to hold true for many years to come. In general, the farmers traditionally practice rice cultivation (1–3 ha),

field crop production, e.g. sugar-cane or cassava, with buffalo and/or cattle (1–3 head). It is therefore essential to account for and integrate the on-farm activities of livestock and to diversify their contribution to increase the farmers efficiency of production and their income.

Mixed crop–livestock based production in which the bulk of the crop yield is used for family consumption and the excess is for local goods exchange or for sale has been practised by subsistence farmers for decades. Recently, a number of countries, including Thailand, have developed a new policy. The aim is to develop livestock–crop production systems to enhance the situation of smallholder farmers, especially their income, in areas where crops cannot be efficiently cultivated. In such areas, land for rice and cassava plantations will be reduced and livestock production, especially of beef and dairy cattle, is being promoted. The Ministry of Agriculture and Co-operatives is committed, to increase the number of beef and dairy cattle by 50,000 and 10,000 head/year, respectively, over the next five years. Small ruminants like goats and sheep are important species raised mostly in the southern part of Thailand. Their potential and future development, and the required research to achieve these goals have been presented by Saithanoo and Cheve-Isarakul (1991) and Saithanoo and Pichaironarongsongkram ( 1989). It is therefore anticipated that the livestock industry will be a major source of income, and livestock–crop production systems could play a critical role in the economy of rural societies.

The livestock economy accounts for about half the total agricultural production when the direct economic value of animal products, are added to the animals' role in providing transportation, draft power for cultivation, manure for cropping and their ability to utilise non-arable land and agricultural residues (Chantalakhana 1990; Devendra and Chantalakhana 1993). However, as environmental issues become of increasing concern, specific measures will be taken that combine efficiency of conversion and productivity, low emissions of methane and capacity to use by-products and crop residues from other primary industries. The significant roles and contributions of beef and buffalo have been reported by Chantalakhana ( 1995) and Wanapat ( 1995).

Chantalakhana (1990) presented in detail the structure and development of production systems, and factors governing small-farm animal production and its sustainability. This study was based on experiences in Thailand and other developing countries which have similar conditions and limited resource availability.

According to Wanapat (1990, 1995), livestock crop based production systems in Thailand could be classified in accordance with their management practices and targeted goals (Tables 6 and 7). The efficiencies of the production systems subsequently depend on availability of on-farm resources, skilful management and market outlets.

**Table 6.** *Type of livestock–crop production systems in Thailand.*

| Type                     | Characteristics/goal                                                                                                                                                     | Livestock and crops                                                        |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| A. Subsistence system    | Minimal input, small in number, draft power, meat, by-products, socio-economic status, naturally available feeds                                                         | Buffalo, goats, sheep, rice, cassava, sugar-cane                           |
| B. Semi-intensive system | More input, herd expansion, better management of shorter duration, targeted market, income generation, secondary or primary                                              | Dairying, finishing/fattening of beef, cassava, soybean, sugar-cane, corn  |
| C. Intensive system      | Labour-intensive, high input, large herd, skilful management, availability and good quality of roughage and concentrates, well-structured market, major source of income | Dairying, finishing/fattening of beef, poultry, swine, rice, corn, soybean |

**Table 7.** *Existing livestock production systems by regions.*

| Species      | Type of production                                     | Regions by highest to lowest  |
|--------------|--------------------------------------------------------|-------------------------------|
| Beef cattle  | Semi-intensive cow–calf/grazing                        | North-east, northern, central |
|              | Finishing/feedlot                                      | North-east, northern          |
| Dairy cattle | Semi-intensive intensive milk/grazing and zero-grazing | Central, north-east, northern |
| Buffalo      | Subsistence production for draft/grazing               | North-east, northern, central |
| Goats        | Subsistence production for meat                        | Southern, others              |
| Sheep        | Subsistence production for meat                        | Southern, others              |
| Swine        | Commercial/intensive                                   | Central, northern, north-east |
| Poultry      | Commercial/intensive                                   | Central, north-east, northern |

## Existing national research institutions and funding bodies: Research and development institutions

The Ministry of Agriculture and Co-operatives (MAC), the Department of Livestock and Development (DLD) and the Department of Agricultural Extension (DAE) are the major arms responsible for national livestock development and extension; they have stations are situated throughout the country. According to the 8th National Economic and Social Development Plan (1997–2001), MAC is committed to increase the number of ruminants and to improve the associated manpower and infrastructure. In addition to the MAC, the Ministry of University Affairs (MUA) administers the following universities where agriculture and animal science courses and research activities have been conducted: Chiangmai University, Chulalongkorn University, Kasetsart University, Khon Kaen University, King Mongkut Institute of Technology-Laadkrabang, Maejo University, Prince of Songkha University, Suranarce Technology University, Thammasart University and Ubolratchanee University. Under the administration of these universities, a number of research institutes specialising in various species and disciplines have been established to undertake relevant research activities, and to offer higher learning opportunities for MS, PhD and post-doctoral degrees.

## **Funding bodies**

The above organisations usually allocate small amounts of money for the research budgets for their staff. However, the major portion of the budget is made available by the following three organisations and awards are relatively competitive:

### **The National Research Council (NRC)**

The NRC is primarily responsible for national research activities and budget allocation. It has a mandate to provide a research budget for all research areas for individual and team research scientists with a budget amount to US\$ 4000/project. In addition, funds for selected research topics are also available up to US\$ 20,000/project.

### **The National Science, Technology and Development Agency (NSTDA)**

The NSTDA is administered under the Ministry of Science, Technology and Energy to promote research and development activities and make available research support in three disciplines: bio-engineering and biotechnology, metals and materials technology, and electronics and computer technology. Projects with impacts on further development and implementation on a large scale are viewed more favourably. Project budgets vary from US\$ 40,000 to larger amounts.

### **The Thailand Research Fund (TRF)**

The TRF is currently established by an endowment fund made available by the government. TRF aims to support fundamental research, applied research, and research and development research. The programme is encouraged to support multidisciplinary research and is divided into the following categories:

- Research and development project
- Research on innovations basically essential for development
- Research to strengthen research institutions
  - Research career development grants
  - Research chair grants
  - TRF designated research centre grants
- Research information dissemination project
- Others

There is no limitation on the project budget to be proposed. Currently, TRF has designated a project on dairy development for support and has sent out calls for proposals.

## **Limiting factors and constraints to livestock production**

### **Nutritional inadequacies**

Large variations in rainfall and soil fertility, and the long dry season, reduce the availability and quality of feed resources. This adversely affects the productivity of dairy and beef cattle, and buffaloes.

## **Inadequacies of breeding stocks**

Under the present production systems, a large portion of breeding stocks, especially dairy and beef cattle and swine, were imported from various countries. This resulted in high investment levels but production remained low, due to heat stress, parasitic infections and low planes of feeding management.

## **Lack of finances**

Since livestock production, particularly ruminant production, is in the hands of smallholder farmers, the availability of funds from various agencies is at present relatively limited and these attract a high rate of interest.

## **Livestock health problems**

Existing health programmes are inadequate and too diversified. Both internal and external parasites add to the overall cost of production and have resulted in the low profile of the existing health control programme.

## **Socio-economic management**

There is no sound socio-economic programme among extension workers, technical personal and farmers to effectively collaborate on livestock programmes with a view to increase production efficiency. Low reproductive performance has also been reported.

## **Limited services and lack of marketing infrastructure**

There has not been sufficient training or development strategies by the government to improve farmers' skills and management in order to support farmers preparations for livestock development. Farmers have too few outlets and channels to sell their livestock products such as milk and beef and often this has resulted in overstorage and deterioration of such products.

## **Livestock research opportunities**

According to the National Research Council of Thailand (1993) and based on the recommendations of a workshop on the need for technology to develop national agriculture in the next decade, the livestock research issues and their priorities were (in order of importance):

- Dairy cattle and swine
- Beef cattle and buffalo
- Chicken, goats, sheep and experimental animals
- Other poultry species (e.g. ducks and geese)
- Pets

The types of research should cover basic, applied and research and development research areas in all disciplines. The ranking of research disciplines for all species is given in Table 8. However, research and development on potential technologies should be highly encouraged and promoted to provide opportunity for researchers and farmers to work together and to disseminate relevant research information.

**Table 8.** *Ranking of researchable disciplines for all species (ranking from lowest to highest, 1–10).*

| Discipline                       | Dairy | Beef | Buffalo | Swine | Chicken | Goats and sheep |
|----------------------------------|-------|------|---------|-------|---------|-----------------|
| Nutrition and feeding            | 10    | 10   | 10      | 8     | 6       | 10              |
| Forage crops                     | 10    | 8    | 8       |       |         |                 |
| Management                       | 8     | 8    | 8       |       |         |                 |
| Genetics and breeding            | 10    | 10   | 10      | 8     | 10      | 10              |
| Reproduction                     | 10    | 10   | 10      | 8     |         | 10              |
| Health                           | 10    | 8    | 10      | 10    | 10      | 10              |
| Milk hygiene and quality control | 10    |      |         |       |         |                 |
| Meat hygiene                     |       | 10   | 10      | 10    | 10      | 8               |
| Meat technology                  |       | 8    | 8       | 8     | 8       | 8               |

Source: National Research Council (1993).

## Conclusions and proposed resource requirements

Based on the existing available resources the following proposals are made for further development and increased efficacy:

1. Research activities in various agro-ecological zones and in proposed species and disciplines need to be carried out:
  - large ruminants (dairy and beef cattle, and buffalo)
  - small ruminants (goats and sheep)
  - non-ruminants (swine and poultry)
2. Research should be undertaken in the areas of animal nutrition and feeding of locally available resources and forage crops, reproduction, genetics and breeding, health, management, meat hygiene and meat technology.
3. Strengthening of existing infrastructure and research facilities by means of interventions and networking at national and international levels to increase global livestock communication and production efficiency.
4. Establishment of research co-ordination institutes for specific areas at national level to strengthen existing activities and to co-ordinate with international bodies.
5. Enhancement and empowerment of researchers engaged in research fields by allocation of appropriate research funding, exchange of knowledge and experiences, training, workshops, visiting scientists etc.

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# Research priorities for improving animal production by agro-ecological zone in Vietnam

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## Abstract

Vietnam can be conveniently divided into seven agro-ecological zones: northern hills and mountains, the Red River delta, northern central coast, southern central coast, central highlands, north-east Mekong Delta or (south-eastern region), and the Mekong Delta. Animal production systems are of three categories: state run semi-industrial or industrial farms, medium size commercial farms, and backyard farms. In order of importance, the major animal resources are swine, dairy and beef cattle, poultry and goats. The main constraints to animal production are breeding stocks, animal feeds, animal health, poor husbandry and lack of credit. The priority areas for research are in swine production, animal feeds, animal health, dairy and beef cattle, poultry and goats with specific issues being indicated under each.

## Introduction

Vietnam is mainly an agricultural country with about 72 million persons living on 331,114 km<sup>2</sup>. Eighty per cent of Vietnamese live in the rural regions, 70% of whom depend on agricultural production for their livelihood. Since 1989, Vietnamese farmers have increased production, making this country third among rice exporting countries with about two million tonnes of rice per year. However, the income and nutritional level of Vietnamese women and children are still below world standards, despite a strong emphasis on food self-sufficiency.

Domestic livestock are raised by lowland farmers and ethnic minorities in the mountainous regions as a subsidiary component of the crop-based farming systems. In 1993, the total animal production share was only 30% of the gross agricultural production. With a per capita intake of 10.4 kg meat, 32 eggs, and 20 ml milk per year (Le Ba Lich 1993), the deficiency in protein intake of the poor people is inevitable. Hence, Vietnam really needs a new strategy and a crash programme in animal production during the next few years to meet the food requirements of its people and to improve their incomes through export of animal products.

As the restructuring of Vietnam's economy gains momentum, the role to be played by the agricultural sector—particularly the animal producers—in generating employment, income, domestic savings, foreign exchange, and food security for the entire country is increasingly becoming a key factor. Unfortunately, Vietnamese farmers are in a disadvantaged position because the price of their products is cheaper than that of industrial products, and to similar products from neighbouring countries. Thus, an appropriate policy on agricultural prices and appropriate production technologies will be essential to encourage the farmers and

sustain their growth. In this paper we try to present the holistic view of the potentials and the realities of Vietnamese animal production.

## The natural setting and agro-ecological zones

Vietnam can be divided into five physiographical zones: coastal, plains, undulating midlands, low mountains, and high mountains. It can be conveniently classified into seven agro-ecological zones (AEZs): northern hills and mountains, Red River Delta, northern central coast, southern central coast, central highlands, north-east Mekong Delta (or south-eastern region), and the Mekong Delta. Each region has its own particular features that need in-depth studies before optimum exploitation can be expected (Vo-Tong Xuan 1992).

Table 1 shows that the total plain area most suitable for rice production is only 4.75 million ha (14.38% of the total land surface). Calculations of food requirements at a population growth rate of 2.1%, suggest that Vietnam can attain food self-reliance to support her own people by the year 2020 and beyond, without forcing *in situ* rice self-sufficiency. On average, agricultural production, including animal products and captured fishery products, contributes 49% of the gross national products and 42% of the total export values (See 'Vietnam Agricultural Sector Review', VIE/88/033, UNDP/FAO/WB/State Commission on Planning). Tables 2 and 3 give information on various crops grown in Vietnam. The sections following describe each region with particular attention to potential agricultural capability and to determine appropriate direction and policy for development.

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**Table 1.** *Land and human resources classified by physiographic and agro-economic regions.*

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**Table 2.** *Food crop project, 1980–1995 (fresh weights, unless stated).*

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**Table 3.** *Selected annual industrial crop projection, 1980–1995 (fresh weights, unless stated otherwise).*

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## Agricultural production in agro-ecological zones of Vietnam

In each of the seven agro-ecological zones, animal production is influenced by the availability of feeding materials, farming practices, and the weather and climatic conditions.

### AEZ 1: The Red River Delta (RRD)

*Climate.* The climate in the Red River Delta and the greater part of northern Vietnam is influenced by the tropical monsoon and by the north-easterly winds giving north Vietnam climatic features distinct from the rest of the country. There are four seasons: cold in winter (coolest months from December to February, 12–18°C), and very warm in summer (warmest months from June to July, 32–34°C). Average total annual rainfall is about 2400 mm, concentrated during July and

August, sometimes causing flash floods submerging newly transplanted rice fields. On average, seven to eight tropical depressions and typhoons strike northern Vietnam each year, often causing damage to crops and property.

*Land resources.* The soils are degraded riverine alluvium. There is minimal replenishment of new sediments due to flood protection structures along the main river courses. As a result, the alluvium is being salinised and becoming more acidic. The land is intensively covered by irrigation systems designed mainly for rice production. Every piece of land appears to be utilised.

*Human resources.* People here are hard working. The population density is the highest in Vietnam, 844 persons/km<sup>2</sup>, and as a result landholding is the smallest in the country.

*Agriculture.* The RRD has a unique potential unequalled by other regions: excellent conditions for high value vegetable crop production on a large scale during the cool months of winter, and for high value fruits such as lychee, small-seeded longan and jujube. Mulberry and silkworm culture are traditional professions. Rice, particularly monoculture rice, is not an efficient crop for the conditions found, but two crops per year are produced integrating cash crops, household animal husbandry, fish farming and gardening. Pig raising is almost compulsory for most farming households because the equally important product from animal husbandry—the animal manure—is composted and incorporated into the rice soil to maintain fertility. The other product—the meat—is produced mostly by a local race, 'I race', which has low body weight (only 50–60 kg at one year of age) but is distinguished by its remarkable adaptation to local conditions and high resistance to diseases and parasites. Broiler production is being developed in this region, contributing substantially to human meat consumption especially in urban areas. Every farm household raises some poultry for family consumption or for the local market. Water buffaloes, previously the common property of the co-operatives are now raised by some families and provide land preparation services to the community. Some households living in coastal areas still practise sericulture as a traditional profession.

## **AEZ 2: Midlands and northern mountainous region (NMR)**

*Climate.* The climate is similar to that of the RRD, with four seasons, but the winter temperature is usually lower, 8–15°C. The annual rainfall averages 2200 to 2400 mm. In the rainy season, flash floods occur frequently because the watershed cover has been greatly denuded. The typhoons affecting northern Vietnam usually reach the NMR also.

*Land resources.* The soils are dominantly degraded grey soils, poor in nutrients—especially phosphorous—and are acidic. Due to heavy exploitation for logging and for food production, severely eroded hills and mountainsides remain dominant features of the NMR. Many of the hills are covered with natural grasses after the rainy season making them suitable for grazing cattle. The undulating hillsides are also suitable for cash crops and some perennial crops such as sugar-cane.

*Human resources.* The inhabitants comprise many ethnic minorities whose population density is extremely low, about 102 persons/km on average. The majority of these people pursue subsistence agriculture using traditional practices. Wherever there are lowland people or educated minority people, modern living is introduced.

*Agriculture.* This region is unique for high value forest species such as tea and fruits (plums, oranges, lychee, medicinal plants and herbs). Upland rice is grown using the slash-and-burn method. Lowland rice is grown in areas with a water catchment. Cattle and especially water buffaloes are popular in these hilly areas. At the subsistence level the local minority groups grow root crops, corn, high value vegetables, beans etc. Sugar-cane is grown on hillsides to produce brown sugar and as feed for the improved pigs raised in some pioneer households (Preston and Leng 1991). Goats are also raised in some households. The local pig breed, called 'Mong cai', is raised as a free range domestic animal by many of the hill people. Like the I breed, Mong cai pigs have a low growth rate but are very hardy and disease resistant. These pigs give firm meat but have thick back fat.

### **AEZ 3: Northern central coastal region**

*Climate.* This region is influenced by a climate similar to that of northern Vietnam up to the Hai Van pass, near Danang. Its four seasons are not as distinct, however. The coolest months of December and January may have an average temperature of 14–16°C; the temperature of the warmest months (June and July) may reach 35–40°C particularly when the Laotian wind blows in June. Rainfall averages 1800 to 2000 mm per annum. An average of seven to eight tropical atmospheric depressions and typhoons may strike the region each year.

*Land resources.* This region is characterised by partly denuded and moderately eroded hills and mountains on one side and sand bars along the coast on the other. The arable soils are degraded and sandy, acidic and very poor in nutrients. The sand bars are being moved by gusty winds, invading the arable areas.

*Human resources.* Population density is about 167 persons/km<sup>2</sup> scattered unevenly. The tendency is to concentrate in small deltaic areas along the coastline. The ethnic minorities live in small tribes up in the mountains. The lowland people are highly artistic and hard working although agricultural production is still traditional.

*Agriculture.* Attempts to install irrigation systems for rice production have been of little success due to inadequate water resources and unsuitable soils. These soils are much better suited to various types of beans and peanuts. Large tracts of hilly areas could be turned into pasture for grazing livestock. At present, herds of cows of 20 to 100 head are being raised by local inhabitants to export unofficially to Laos and Thailand. Usually the children are assigned to the herding job, moving the cattle from one area to another in rotation depending on the availability of grassy hills. Pig raising is a 'must' component of rice-farming households. In Thanh Hoa province, duck raising is more popular in lowland rice areas. Recently in Nghe An and Ha Tinh provinces, deer husbandry has been taken up by several households, mainly for the horns.

### **AEZ 4: Southern central coastal region**

*Climate.* This region has mainly two seasons like the rest of southern Vietnam. It is hot during the dry season, with the temperature averaging 32–36°C. The rainy season gives less than 1400 mm of rainfall per annum; the driest locality of the country is Phan Rang, which has only 800 mm of rainfall per annum. The coolest months (December to January) are in the range of 20–22°C. Typhoons occur in this region almost as often as in the northern central coastal region.

*Land resources.* The landscape is similar to that of the northern region, except that there are larger deltaic alluvial areas that can support better rice production. Arable lands are strongly eroded sandy silt, very poor in nutrients. Moving sand bars are threatening arable lands.

*Human resources.* The population distribution is very similar to that in the northern region. The average density is 148 persons/km<sup>2</sup>. The indigenous people are very artistic and hard working.

*Agriculture.* Aside from good rice production in the major alluvial deltas, this region is famous for the best medicinal and spice plants (especially cinnamon). Sugar-cane, coconut, fruit trees, grapes, cotton, beans and sesame can be produced here successfully. Mulberry and silkworm culture are traditional professions. Herds of up to a few hundred beef cattle named 'Vang Phu yen' are locally renowned because of their good performance and good quality beef. They are locally exported to Ho Chi Minh City in the south and contribute a large part of local beef consumption. This region is also famous for its goat meat production especially in Phan Rang district where the rainfall is the lowest in the country. The local goat breed is quite productive and resistant to the dry conditions. Water buffaloes are kept by small farms for draft use. Pig production with the small-size local breed called 'Heo Co' (or 'Heo Moi') in remote areas, and with improved breeds (mostly Yorkshire) in urban areas, is just sufficient for local consumption. The household farming systems include poultry production with broilers. Layers and ducks which provide extra income to the families.

## **AEZ 5: Western high plateaux**

*Climate.* The mild temperature and humidity of this region are favourable for high value crops. The coolest months are December and January and temperatures are usually 15–18°C; temperatures in warmest months of May and June are 28–30°C. The rainfall is from 1800 to 2400 mm per annum.

*Land resources.* Most of the soils of the western high plateaux are reddish brown basalt, rich in nutrients when properly covered. Unfortunately, due partly to the war and partly to wanton exploitation by new settlers, tens of thousands of hectares of precious forest have been felled. The soils are denuded and exposed to severe erosion, and are becoming acidic. Their nutrients are depleted, especially of phosphorous and bases. Several denuded, smooth hills are very suitable for pasture. A large part of the region is still not cultivated.

*Human resources.* The population density is only 45 persons/km<sup>2</sup>, comprising an integration of lowland Vietnamese and several ethnic minorities. Technological know-how is limited, and the inhabitants live mainly by traditional means.

*Agriculture.* This region is potentially capable of producing the major industrial crops for the country, such as rubber, tea, coffee and fruit trees. The best mulberry and silkworm production can be found here. Pines and precious forest trees are to be planted. High value vegetables thrive best when irrigation is assured. Lowland rice is grown in irrigated valleys, otherwise ethnic farmers practise slash-and-burn cultivation of upland rice. Due to a lack of income, the local population seldom raises any valuable animal, except a few keeping free-range local breeds of pig or chicken. Small herds of cattle are kept by some middle class families. The climatic and natural conditions of this region are suitable for chicken and dairy cattle production.

## **AEZ 6: Southern region**

*Climate.* Moving towards the south, the climate becomes warmer. The temperature does not fluctuate as much as in the northern regions. The coolest months of December and January have a range of temperature from 22–23°C while the warmest months of April and May are in the range of 32–33°C. The annual rainfall is 1400–2200 mm.

*Land resources.* There are two major soil groups: reddish brown basaltic soils adjacent to the highlands, and degraded grey soils with patches of acid sulphate soils adjacent to the Mekong Delta. Both soil groups are being eroded due to exploitation of forests and previous defoliation during the war. Presently, large parts of the land resources of this region are still underdeveloped.

*Human resources.* Since Ho Chi Minh City is included in this region, the population density is 332 persons/km<sup>2</sup> (if Ho Chi Minh City is excluded, the density is only 183 persons/km<sup>2</sup>). The mountainous areas are inhabited by many ethnic minorities who live at the subsistence level. The highly trained, lowland Vietnamese live in big cities, capable of providing all sorts of skills needed for agricultural and industrial activities.

*Agriculture.* Rubber and high value fruit trees are traditional products of this region. Coffee and tea are also found. Other speciality crops such as cashew nut, black pepper, banana, sugar-cane, peanut, soybean, mungbean, cowpea, sweet potato, cassava etc can grow very well. This ecosystem is also suitable for many types of animal husbandry including poultry, cattle, goats and pig. Various farming systems involving the integration of some of these components are being practised. Commercial scale husbandry of pigs and chicken is being practised by several enterprises with high technology. This region is the centre of parent stock farms, providing commercial poultry and livestock for the whole southern part of Vietnam.

## **AEZ 7: The Mekong Delta (MD)**

*Climate.* With the Camau peninsula washed by the eastern sea (South China Sea) and the Gulf of Thailand, the monsoonal climate of the MD is regulated by the flow of the lower basin of the Mekong River system and the tidal movements of both the western and eastern seas. The monsoons bring 1400–2400 mm of rainfall per annum which is combined with the high flow of the Mekong system in September and October (40,000 m<sup>3</sup>/sec) causing the annual flood of the entire delta. In depressed areas, such as the Plain of Reeds and the Longxuyen quadrangle, water depth during the flood may reach 80 to 200 cm, while the back swamps behind the coastline are inundated to about 50 cm. During the dry season, the water table moves deep into the soil profile, causing localised drought. The average temperatures range from 23–25°C during the cool months of December–January to 32–33°C in April.

*Land resources.* The majority of the soils of the MD are young alluvium. About 40% of the area is affected by problem soils (acid sulphate soils and seasonal saline soils) (Nguyen Bao Ve et al 1989; Soil map of the Mekong Delta. Report to Programme 60–02, State Commission on Science, Ho Chi Minh City). About 400,000 ha of problem soils are still unexploited.

*Human resources.* The region is inhabited mainly by Vietnamese, Cambodians, Chinese, and a small number of Cham people, at a population density of 355

persons/km<sup>2</sup>. However, the population distribution is quite uneven: few people live on the problem soil areas where land resources are untapped. Many talented people have been settled here for centuries.

*Agriculture.* This is the rice bowl of Vietnam. Although a large part of the land is suitable for rice, various rice-based farming systems involving aquaculture, animals, cash crops and fruit trees have proven more profitable than rice alone. For aquaculture, fresh and saline water shrimps can be raised successfully within the rice fields. Large areas of mangroves have been zoned for environmental management. Large areas of extremely acid sulphate soils are suitable for various economic crops such as pineapple, sugar-cane, jute, kenaf, cassava, and *Eucalyptus* and *Melaleuca* forests. On riverain alluvium, large fruit tree orchards can be established to grow mango, pomelo, oranges, durian, star apple etc. The MD is particularly suitable for raising ducks, free ranging native chicken and water buffalo, and for two famous indigenous breeds of pig, the Baxuyen and the Thuocnhieu. The Delta is not only the main supplier of rice to the whole country but also of products from pigs, ducks, chickens, cattle to Ho Chi Minh City. Most farming households raise pigs (mostly local breeds, some improved breeds such as Yorkshire and Landrace) and chicken. Some families professionally raise ducks by the thousands, herding from one rice field to another throughout the year. In the mountainous region of Tri Ton and Moc Hoa, adjacent to Cambodia, and high elevation areas of Tra Vinh and Soc Trang, native cattle are a component of the Khmer farm households. Traditionally, the Khmer people raise cattle not only for draft use but also for entering into the livestock market at the border with Cambodia. The number of water buffalo is decreasing due to farm mechanisation and slaughtering for meat.

## Animal production systems

Animal production systems in Vietnam are largely traditional, providing the most immediate needs of the farming households. These systems depend largely on crop production practices within each farming community. The traditional management practices for indigenous breeds of the region include feeding the animals with available by-products of crop production (rice bran, broken rice and waste paddy), crop residues (rice straw, sugar-cane tops, bagasse and banana stems), or with whatever green matter is produced by the family (sweet potato or *Ipomea* vines) or occurs naturally (low quality native grasses) in the free land. Therefore animal yields are generally low but so is the production cost.

During the last two decades, attempts on the part of the government have resulted in improved breeds of cattle, pigs, goats, chickens, ducks etc. The farming families conveniently raise pigs and chicken as a necessary component of farming systems. Table 4 shows the numbers of livestock produced since 1980. At present, it is estimated that in Vietnam there are around 15 million pigs, 3.2 million beef cattle—including 15,000 milking cows—3 million water buffaloes, 0.4 million goats, and 130 million head of poultry. Based on a per household basis, a better income family raises 4.1 water buffaloes or 2.9 beef cattle and 4.5 pigs while poorer families could afford only 0.05 water buffalo, 0.05 beef cattle, 0.42 pigs and 3.4 chicken (Nguyen Van Tiem 1993). Animal resources are unequally distributed geographically. The main distinction is between the densely populated lowlands in the farming systems, and the sparsely populated highlands where most grazing areas are found. According to FAO/UNDP (1989) the RRD and the MD together account for more than half of the country's pig population and pork output, and

64% of ducks, while 59% of the cattle are in the central highlands and coastal zones, and 43% of the buffalo are in the northern mountain and midland areas.

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**Table 4.** *Livestock production and projections (1980–1995).*

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Three main animal production systems exist: state-run semi-industrial or industrial farms, private medium size commercial farms and backyard household farms.

**The state-run semi-industrial or industrial farms**

This category comprises about 5% of total production. Each of these farms usually raise 500–1000 sows, 300–1000 dairy cows, or 20–40,000 head of poultry. These farms are located in all the AEZs and are charged with the supply of commercial animals to the private commercial farms or village households. Usually each provincial department of agriculture has to establish such farms but due to financial and technical constraints, not all the provinces have done so.

**The medium size commercial farms**

There is a growing interest among private producers who want to specialise in animal production, particularly swine and poultry for meat or eggs. Each farm usually raises from 100–400 sows, 1000–10,000 broilers or layers and 10–100 dairy cows. The government is encouraging the participation of the private sector in this area.

**The backyard farms**

This is also popularly known as 'saving bank livestock' and is the most widely practised by farming households throughout the country since the animals, such as pigs, chicken, water buffaloes, cows, goats, horses etc, range freely and can pick up farm by-products to feed themselves. The husbandry especially makes use of the free time of women and children in the family. For many households—particularly those living in the hilly or mountainous regions—backyard animal production constitutes a substantial part of their income and is important for family celebrations and special occasions.

**Constraints to production**

The animal production sector has grown substantially during the past two decades (Table 4). Aside from the increase in the animal population, the quality of animal breeds has also been improved. In pig breeding, the lean meat portion of Vietnamese pig meat which used to be less than 40%, now attains more than 50%. Simultaneously with breed improvement, animal husbandry science and technology continue to be improved together with animal feed processing technology to meet the increasing demand for better livestock production in the country (Le Thanh Hai 1985; Le Thanh Hai and Che Quang Tuyen 1994). However, there are multiple constraints that the animal production sector has to face. These are well documented in FAO/UNDP (1989).

## Breeding materials

Indigenous breeds predominate for all animals types (with a partial exception for pigs), and they are characterised by low genetic potential for meat, milk, and egg production, small body size, and slow growth rates. Some species, such as native cattle and buffalo, are late maturing types. Native pigs (Mong cai and I) have low body weight and produce too high a proportion of fat. Poultry breeds are small and have low meat:bone ratios. Fortunately, all indigenous breeds generally possess good resistance to various infectious diseases and are tolerant of the adverse climatic and natural conditions in the rural areas. For swine production, the existing inferior stock of breeders needs to be further improved to raise the meat yield and quality. Indigenous breeds are unsuitable for intensive animal production, but they are highly preferred by the upper income people because of the good quality of their meat. Breeds of poultry, dairy cattle, water buffalo and goat need to be improved. Presently, Vietnam lacks a grandparent stock farm.

## Animal feeds

There is low utilisation of the major feed crops for animals, since maize, soybean, peanut, and even cassava and sweet potato are presently used more for human consumption because their market prices are quite high, making it unprofitable to use them as animal feeds. Crop residues such as rice straw and bagasse are fed to animals with very little or no treatment, and the resulting utilisation of these feeds is low compared with the potential of treated residue.

Most of the best natural grasslands have been reclaimed for crop production or resettlement, and the new grasslands resulting from deforestation have been subject to shifting cultivation which leaves behind only fire-tolerant grasses of low forage value, such as *Imperata cylindrica*. The open-access pasture, not subject to any form of management, is readily overgrazed and tends to further degenerate. Nor are technical solutions readily available in the northern hilly areas, where high summer temperatures reduce yields of cool season grasses and legumes. In addition, tropical legumes cannot easily survive low winter temperatures. Due to the complete absence of legumes in the pastures, the protein content of ruminant forage is always below physiological requirements. Rice straw and other crop residues are deficient in protein, and milling by-products lack essential amino acids. Locally produced peanut, soybean and coconut oil cakes, and fish meal are therefore the main sources of supplementary protein. Even then, the high market price and the low quality of these materials continue to create a protein deficiency in Vietnamese animal diets.

There are a few modern animal feed mills, established by some foreign investors, which produce superior feed and feed additives for the intensive animal growers. However, most local feed mills, either operated by the state-owned enterprises or private enterprises, are obsolete in terms of equipment and in the technology required for feed analysis and feed formulation. Due to these limitations the producers do not receive enough advice to make efficient use of the abundant local materials such as dried fish, oil cakes, corn, rice brans, sea shells etc. Therefore, although the unit cost of feed is not high (but often fluctuates with the seasonal cropping pattern), the conversion rate is so high that most of the time the animal

growers do not make much profit. In contrast, the foreign feed mills turn out superior products which easily meet the demand of intensive animal growers.

## **Animal health**

Recommended veterinary measures have not been transferred or strictly and systematically enforced by local veterinary units. The lack of modern equipment to carry out advanced techniques in diagnosing animal diseases quickly and correctly is the main constraint to eradicating animal diseases. Furthermore, due to the poor knowledge of animal diseases, farmers often ignore warnings from veterinary workers, thus increasing the risks of outbreaks of infectious animal diseases occurring in the rural areas. Free range animal production systems tend to spread diseases easily from one place to another. Unfortunately, cheap and effective veterinary medicines are often not sufficient in remote areas for the poorer growers.

In many rural areas, particularly in some parts of AEZ 7 where swampy conditions prevail, mosquitoes pose a big problem for animal production. Farmers usually have to provide mosquito nets for water buffaloes, cows, and pigs to minimise adverse effects on these domestic animals.

## **Husbandry skills**

Almost all household producers follow traditional practices and extensive management systems. The backyard growers do not give prime attention to routine standards of animal house sanitation, vaccination programmes, and feed composition. In extensive cattle grazing, there is a tendency for farmers to try to expand herd size even when existing animals are poorly fed on overgrazed grasslands. Among other reasons for this practice is perhaps that the minority people tend to equate herd size with wealth. The more advanced farms have not yet applied modern technology such as computer programmed management and feeding programmes.

## **Prices of inputs and outputs**

The government does not have a clear pricing policy for the animal production sector; neither does it have any subsidy of any kind. As a consequence, animal producers in Vietnam are always subject to the fluctuation of the market prices which can sometimes cause large losses or, occasionally, put them out of business. Since the majority of pork producers are farm households, their main source of feed is rice bran whose quantity varies according to the status of rice exports. When rice export slows down, there is little bran in the market. The price of bran appreciates while that of pork remains low, and farmers unable to sustain the losses sell their animals, including the breeding piglets, at any price. The large supply of pork further lowers the price of pigs until the number of piglets becomes too small. At that time rice bran becomes available again and at a cheaper price, whilst the price of piglets increases.

## **Lack of credit for the small farmers**

Millions of small farm households are unable to take the advantage of integrating animals into the farming system due to lack of capital. According to a survey organised by the Ministry of Agriculture and Food Industries in 1992 (Nguyen Van

Tiem 1992), the average better income ("rich") farm families, which comprise only 15% of the total farm population, have 5.5 persons and earn VN Dong 1.95 million per capita (US\$ 195), while the majority of the rural population has 5.8 persons per family and earns VN Dong 0.25 million per capita (US\$ 25). The poorer families cannot easily take loans from the agricultural bank as they have no collateral. Poverty is often accompanied by technical ignorance among small farmers, therefore any new technologies must be appropriate to the actual situation of the households.

## Research issues

Considering the present situation of the animal production sector and in line with the economic development masterplan of Vietnam, the Ministry of Agriculture and Food Industries has set forth the following objectives for animal production in the immediate future:

Gradually transforming subsistence animal husbandry into commercial animal production, and integrating feed production and processing with animal production needs.

Developing all types of livestock, with emphasis on backyard livestock and poultry which have good markets, both domestic and export. Pig production will be central, while beef cattle, buffalo, chicken and duck are given next importance, to achieve an animal production target of 1,360,000 t live weight of all types of consumable animals. In 1995, the per capita meat consumption was 13.6 kg compared with 10.1 kg in 1989.

To meet the above objectives, the government will have to consider a set of incentive policies for the animal sector, and will need more investment in animal production infrastructure and research. To achieve this, the government will direct an all-out effort in integrating livestock in various appropriate farming systems in all the agro-ecoregions in Vietnam. The research issues are suggested below in order of priority.

### Swine production

- To achieve 1 million tonnes of pork live weight in 1995 and gradually increase this to 1.35 million tonnes by the year 2000, there should be a strong programme in accelerated hybridisation to create a hybrid between a resistant local breed (Mong Cai, Thuoc Nhieu or Ba Xuyen) and a high yielding and lean meat breed (Yorkshire etc). The hybrid should have a lean meat proportion of more than 50%, and at least 85 kg at commercial weight.
- Increase application of Mong Cai breed in the northern provinces (AEZs 1, 2 and 3), preferably within appropriate farming systems.
- Increased application of lean-meat type pigs such as the Yorkshire breed in the southern provinces (AEZs 4, 5, 6 and 7), also within appropriate farming systems.

### Animal feeds

- Accelerating a national research programme on animal nutrition and feeding aided by biotechnology using locally available feed materials with minimal imported additives (for example in AEZs 3 and 4, where wastes from shrimp

freezing plants are plentiful; these can form special feed for ducks and swine that is highly nutritious). Applying modern feed processing technology to produce high quality animal feeds at the right time and in sufficient quantity for every type of animal in the humid tropics.

- In AEZ 2, hillside sugar-cane seems to be a good feeding material in household swine production. More in-depth research on this farming system should be carried out to improve the income of highland farmers.
- Pasture development: In AEZs 2, 3, 4 and 5, thousands of hectares of pasture can be established for cattle husbandry, for meat or milk. The production of the above crops and animals can be well integrated into various sloping and farming systems. Therefore, the selection of appropriate legumes and grasses for forage production at each AEZ should be carried out as soon as possible. On acid sulphate soils in AEZ 7, acid-tolerant forage crops should be selected and their appropriate production techniques should be developed to extend cattle production into marginal lands.
- Improving the yields, production and processing of maize, tubers, soybean, and peanut should have higher priority.

## **Animal health**

- Continuing research on improving animal health through improving diagnostic capability
- Developing control and preventive measures for tick-borne diseases.
- Improving animal health protection facilities (drug and vaccine production).
- Improving the veterinary extension system in the rural areas.

## **Dairy and beef cattle**

The target for cattle is 4.375 million head, of which 15,000 are dairy cows in 1995, increasing to 53,000 hybrid dairy cows by the year 2000 (Ministry of Agriculture and Food Industries (MAFI) 1990).

- Improved maintenance and acclimatisation of the original Holstein breed from Holland.
- Accelerating the national hybridisation programme through the use of the Indian Red Sindhi breed, the Sindhi breed, Sindhi hybrids, or selected large sized local breeds to improve the local breed.
- Improving the breeds of water buffalo for all AEZs for draft power and for meat.
- Integration of beef or dairy cattle and water buffalo in livestock-based farming systems in AEZs 2, 3, 4, 5 and 6 wherever suitable. Particularly in AEZ 5 where coffee, tea, and rubber plantations are abundant, the integration of cattle into the plantation can be mutually beneficial.

## **Poultry**

Continuing the improvement of chicken breeds to introduce into commercial farms (AEZs 6 and 7). Improving the local duck breed (Vit Tau, a semi-foraging duck)

for use in rice-based farming systems in AEZs 6 and 7 through selection, feed improvement, and health protection.

## **Goats**

Improving local breeds or introducing a new breed of goat—especially dairy breeds—and developing appropriate husbandry techniques for use in upland, crop-based farming systems in all AEZs.

## **Livestock-based sustainable farming systems**

While commercial farms should be encouraged as market demand grows, the best approach to alleviating rural poverty rests in assisting farm families to integrate improved livestock into their farming systems. The research on sustainable livestock systems will be accelerated using the best technologies generated by the above research activities.

## **Resource requirements**

As Vietnam's economy develops, the market demand for livestock products will increase with the increase in the income of the consumers. Future planning should increase favourable conditions to meet the changing demand. The most critical condition is provision of a surplus of cereals and other feed ingredients over direct human consumption requirements. Lacking such a surplus, meat production can only grow as fast as by-product availability.

The Animal Production and Veterinary Department of MAFI has the overall responsibility for subsectoral policy and planning in co-operation with the Agriculture and Food Department of the State Planning Commission. This covers direction and co-ordination of breeding and technology transfer, production and marketing, veterinary services and feed utilisation, and direct control of specialised livestock and feed companies and research institutions. To support these programmes and activities the country needs continued and stronger investments in infrastructure, organisation, expertise, modern but appropriate technologies and, particularly, new breeds of animals. Most of the distinct institutions under MAFI management and guidance suffer from perpetual cash flow or investment shortages and operate at low levels of efficiency.

## **National research capacity and existing international programmes**

The research and development capacity in the Vietnam livestock sector includes the institutions under MAFI management or guidance, the agriculture-related universities and colleges under the management and guidance of the Ministry of Education and Training, and the Provincial Animal Husbandry Departments—many of which have been transformed into Provincial Animal Production and Support Companies—in 53 cities/provinces in Vietnam. The most outstanding of these institutions include the following:

*Animal Breeding and Feed Production Company.* This was formed in 1989 to direct the activities of various state farms in dairy cattle and pig breeding, cattle and pig artificial insemination (AI) and mills for compound feed production. Its assets include five feed mills supplying 30–40 thousand tonnes of concentrate to

northern pig and cattle farms (another 43 large-capacity feed mills exist with about 500,000-t annual capacity and under 50% capacity utilisation, due to raw material shortage), three cattle AI centres, two regional AI centres, five provincial AI stations, and nine pig breeding centres.

*Union of Poultry Enterprises.* Founded since 1974, this company manages 15 chicken and three duck breeding farms, two feed mixing plants, one research centre and one poultry technician training school.

In the southern region (AEZs 5, 6 and 7) 11 poultry parent stock breeding companies (including one privately owned) are producing day-old chicks of the following breeds:

- Layers: Isabrown (French), Brownick and Hiline (American), Goldline (Dutch).
- Broilers: AA, Cobb, Avian and Hubbard (American).

*Veterinary service.* The state-run veterinary service, with a pyramidal organisational system, was merged into the livestock department of MAFI in 1989. A Veterinary Diagnostic Centre and a Veterinary Research Institute are located in Hanoi and a separate veterinary research institute operates in the south. The Network includes Animal Quarantine and Animal Sanitary Inspection centre and four other regional veterinary subcentres. Each province has its local veterinary service and small stations exist at the district level. Subsidised compulsory vaccinations cover some 80% of the livestock, with the major part of the costs borne by the farmers. Priority in disease control and prevention is given to export production zones, mainly in the south. Diseases include anthrax, foot-and-mouth disease, bovine pasteurellosis, and swine fever.

*Veterinary medicine factories.* One each in the north and the south produce some simple vaccines and medicines from imported ingredients. Other products are imported but locally-available vaccines, medicines and antibiotics are in short supply and generally of low quality. Aside from central government imports, totalling about US\$ 4 million per annum, trading companies and private traders contribute to domestic supply.

*Provincial Department of Agriculture, Animal Husbandry and Veterinary Section.* At the provincial level, animal breeding and feed production, veterinary services and veterinary medicine factories are dealt with by the Animal and Veterinary Section of the Provincial Department of Agriculture. Many of these units have been transformed into service companies serving the same purposes at some cost to the producers.

*Education, extension and training.* Training in animal husbandry at graduate and post-graduate levels as well as technician level is carried out both at agricultural universities and research institutes. At present these activities are concentrated in the following institutions:

1. Animal Husbandry Research Institute, Hanoi
2. Veterinary Research Institute, Hanoi
3. Southern Institute of Agricultural Sciences, Ho Chi Minh City
4. Southern Veterinary Centre, Ho Chi Minh City
5. Moncada Centre, Ba vi, Hanoi
6. Agricultural University I, Hanoi

7. Agricultural University II, Hue
8. Agricultural University III, Bac Thai
9. University of Agriculture and Forestry of Ho Chi Minh City
10. University of Tay Nguyen, Buonmathuot
11. University of Cantho, Cantho
12. Agriculture and Forestry College of Hasonbinh, Ha dong
13. Agriculture and Forestry College of Thanh hoa, Thanh hoa
14. Agriculture and College of Long dinh, Tiengiang province

A number of international co-operative projects to assist the livestock development programme of Vietnam have been granted by international agencies such as UNDP/FAO (VIE/80/012 Veterinary Research; VIE/80/013 Milk Production; VIE/86/006 Veterinary Health II; VIE/86/007 Duck Production Improvement; VIE/86/008 Beef R & D; and VIE/86/009 Chicken Development).

Bilateral assistance includes the following on-going projects: Beef cattle and pasture development (International Development Research Centre, Canada), livestock-based farming systems research and development (joint FAO-SAREC); swine breeding (INRA, France), evaluation of breeds, breeding, and feeds for pigs (ACIAR, Australia). Several NGOs (most notably Heifer International, USA) have been assisting small farmers with credit and piglets to improve poor farm household income.

## Conclusion

In the development process, the Vietnamese livestock sector is facing multiple difficulties and challenges. Although the government has been trying to create favourable conditions, and there has been some international performance of the sector, the progress so far is still slow and does not meet the full expectations of farming households. Obviously there is an urgent need for a better approach to sector development from the organisation stages to the management of research and extension in livestock production. We hope that there will be strong co-operation, with firm commitment, in scientific research and technology transfer. The collaboration of expertise from individual scientists and institutions from the Asian region will be most welcome. Based on the success stories of the International Rice Research Institute (IRRI), we think that the most direct, systematic, and effective assistance would be from an international centre which possesses a full range of experts specialised in all the aspects of the commodity concerned. In livestock development, we hope that the International Livestock Research Institute (ILRI) could duplicate the approach that IRRI has been using for Asia. A subcentre of ILRI in Asia would be particularly welcomed by Asian countries.

## Acknowledgements

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# Research priorities for livestock agriculture by agro-ecological zone in Lao PDR

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## Abstract

The agro-ecological zones (AEZs) in Lao PDR are of three categories: upland, plateau and lowland. Detailed descriptions of each and the type of animal species found in each are given. Several constraints to livestock production are indicated and these include inadequate manpower, funds, research facilities, animal health and feed shortages. Research priorities for each AEZ are indicated. Agroforestry and its combination with livestock and the provision of credit to mitigate the effects of slash-and-burn agriculture on the natural resources and sustainable income of farming families in the uplands is stressed. Supplementary feeds and nutrition are especially important in the lowlands while forage selection and pasture improvement are required for the plateau region.

## Introduction

Livestock production in Lao PDR is supplementary and complementary to crop production. The livestock production systems presently being pursued are low input–low output systems.

Buffalo are needed as draft power for rice cultivation. Currently more than 95% of the farmers use buffalo to plough their fields. Bullocks are used for ox-carts to carry agricultural products to the market. The farmers keep buffalo and cattle as a savings bank and sell them when there is an emergency need. Livestock are the most important source of cash income: surveys have indicated that more than 50% of household cash income comes from livestock, and livestock could provide an important source of sustainable income for their families. The cattle industry has the most potential for development in the upland regions because the animals do not compete for human food and there are vast rangelands in this region. In 1994 there were about 1.2 million head of buffalo, 1.072 million head of cattle, 1.5 million pigs and about 9 million poultry. Figure 1 illustrates the size of cattle and buffalo populations between 1975 and 1994.

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**Figure 1.** *Size of cattle and buffalo populations in Lao PDR, 1975–94.*

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The general objectives are to derive improvement in livestock productivity and efficiency in income generation for poor subsistence families through the stability of agricultural income and food sources. This should be sought through long-term sustainability of natural and human resources and the distribution of benefits from development to less advantaged farm families, including women.

The government policy for the agricultural sector has been formulated as follows:

- to achieve food self-sufficiency

- limit slash-and-burn shifting cultivation
- promotion of animal production to supply domestic demand and surplus for export
- rural development.

## Agro-ecological zones

In Lao PDR there are three main agro-ecological zones: the uplands, the plateau and the lowlands. Of these agro-ecological zones the upland and the lowland areas are the priority for livestock research and development; the Bolovens plateau is more suitable for forestry development.

### The uplands

The uplands are the mountainous lands from 1100 m to 3000 m above mean sea level. They comprise about 60% of Lao PDR, mostly in the north with a narrow strip along the Vietnamese border in the south. The highest mountain is Phu Bia (2820 m) in Xiengkhouang Province. The natural forest is largely degraded. The majority of the soils are red yellow podzolic and reddish brown laterite soils. There is a sandy clay topsoil which becomes of finer texture in the subsoil (alleviation), with the higher leached soils being acid (pH 4.5–5.8) and with low cation exchange. The climate is mainly subtropical wet, with dry areas in the north.

The upland farming system is at the subsistence level with little or no surplus produced and conducted as slash-and-burn farming on mountain slopes. A wide range of crops such as upland rice, maize, root or tuber crops are produced. The average household grows about 1 ha of upland rice (non-glutinous) and 1 ha of maize.

Livestock include cattle, pigs, poultry and some horses. The generated income for the family is mainly derived from selling livestock, crop and forest products. The cropping system was probably ecologically stable 20 years ago, but because of government restrictions on clearing primary forest and rapid population growth, the system is no longer sustainable due to the decreasing fallow period.

The upland area is populated predominantly by the Mong people who practise slash-and-burn shifting cultivation. Although many Mong villages are located at altitudes below 1000 m, communication problems and the absence of markets for most agricultural products limit options for upland farmers.

### The plateau

The plateau is the area between 800 and 1300 m above mean sea level. There is a tropical monsoon climate with annual rainfall of from 2000 mm to 4000 mm mainly falling from May to September (80%). Temperatures have an average annual range of 20°C to 31°C with a range of 15°C in December to 35°C in April. Natural vegetation consists of savannah forest and grassland. Some of these areas are used for cultivation but most is mainly used for extensive grazing of livestock. The most favourable plateau soils are found on the Bolovens Plateau, where extensive deep brown basaltic soils are found. These soils are suitable for fruit trees, coffee and other crops.

The farming system in this zone mainly consists of slash-and-burn agriculture and the introduction of tree crops. Coffee is the main crop and includes the Robusta, Arabica and Liberica varieties. The average household has a coffee area of 1–3 ha. The yield is about 500 kg of green beans/ha. Slash-and-burn for rice production has also been practised, but it provides only a low yield due to the short fallow.

Cattle, pigs and poultry are the most important components in this region because they provide protein and supplement incomes for the family. Cattle production is the most important source of cash income.

## The lowlands

The lowlands are the plains lower than 800 m above mean sea level. These zones cover about 20% of Laos and occur along the flood plain of the Mekong River and in the flood plains, fans and valleys of its tributaries. This zone falls into the tropical wet and dry climatic zone having a highly seasonal rainfall of about 1300 to 1700 mm falling mostly in May to September (75%). Although rainfall is high, it is variable both in location and timing. During the cropping season there is often a short dry period in June causing moisture stress at critical stages of crop growth. Temperatures have an average annual range of from 32°C to 21°C with a minimum of 16°C in December and a maximum of 36°C in April. Natural vegetation, which consisted of lowland forest, has now been largely removed for cultivation and secondary forest and is used for gardening and grazing livestock. The flood plains comprise low humid grey soils and recent river alluvia. On the older, slightly higher terraces the soils are formed of old alluvium and consist mainly of podzol and laterite. The land is generally suited to a wide range of crops. The most common crop is rainfed lowland rice.

In this zone, farming is mainly concentrated on rainfed lowland rice production during the wet season. Traditionally, glutinous varieties predominate with the growing season starting in mid-May to June. The first

seedling bed preparation and planting take place in late June to early July. Very few farmers apply inorganic fertiliser or use insecticides but animal manure is used.

Harvesting, threshing and winnowing are done in mid-October for early maturing rice varieties but for late-maturing varieties, harvesting time is in mid-November to early December. After harvesting, rice paddy fields are used for grazing. However, in some areas where irrigation facilities are available, a second cropping in the dry season is undertaken. The average yield experienced in the lowland is about 2.2 t/ha for the rainfed paddy and 3 t/ha for irrigated paddy, although where there are high inputs (fertiliser, insecticide, pesticide etc), the yield can reach up to 3.5–4 t/ha.

Livestock such as buffaloes, cattle, pigs and poultry are raised in this zone integrated with crop production. Figure 2 illustrates the distribution of livestock by agro-ecological zone.

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**Figure 2.** *Livestock population in different agro-ecosystems.*

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## Past and present research

Livestock research work in Lao PDR is currently very limited. There are two types of projects: research projects which only have research and training activities and development projects which have research components in support of development activities.

The Australian-funded Livestock Development Project was initiated at Nam Suang Livestock Development Station in Vientiane Municipality in 1985 with the aim of developing forage-based cattle production systems.

An IDRC-funded Indigenous Fisheries Development Project began its implementation in 1991. This is the first research activity to focus on indigenous fish species with the aim of conservation and preservation of the local biodiversity. This project is based on Khong island in Champassak Province bordering Cambodia and focuses on fish biology, riverine ecology and socio-economics.

Indigenous pig research was carried out at Nong Teng station and on-farm with farmer participation by an NGO-funded project (CUSO), in order to study the impact of nutrition on the productivity and reproductive quality of the local pig and its crossbreeds.

Several activities on the better use of locally available feed resources are conducted by a Japanese funded FAO-regional project in collaboration with some countries in the region.

Some activities on dairy cattle improvement have been undertaken by foreign investors such as Asia Tech Farm on the Bolovens Plateau, and Burapha Development Consultant Co. Ltd in Vientiane Municipality. These are private sector ventures.

## Livestock and fisheries research institutions

The Livestock Adaptive Research and Extension Center is responsible for cattle pasture research and there are three stations (at Nam Suang, Xiengkhoung and Bolovens plateau) where the research work is carried out.

The Small Animal Adaptive Research Extension Center (Nong Teng) is responsible for small animal and fisheries research. There are fisheries stations (at Nong Teng, Luang Prabang, and Pakse), and a pig farm to support research and extension on aquaculture and small animals.

## Constraints to livestock production

- Lack of national research capacity and capability to improve animal production for different agro-ecological zones.
- Limited research facilities.
- Lack of skilled manpower at all levels (central, provincial and district).
- Limited funds for research work. Only a few research activities have been carried out and these are predominantly donor supported within projects.
- There are many dangerous diseases: haemorrhagic septicaemia, foot-and-mouth disease, hog cholera, fowl cholera and Newcastle disease.

- Feed shortages in the dry season. In irrigated areas, there are feed shortages in the rainy season due to the limited grazing area.

## Research priorities

There is a need to carry out farming systems analysis in all target areas within the different agro-ecological zones to serve as a pre-condition and a basis for determining the appropriate type and level of technical and technological interventions.

### Lowland

On-farm testing of technology for key nutrition aspects, such as better use of crop residues and by-product to increase and sustain productivity of pig and poultry is required to meet domestic demand.

- Research study on the Yellow Asian cattle.
- Urea-treated rice straw and agricultural by-product utilisation.
- Production of molasses–urea blocks.
- Mineral supplementation for the mineral deficit areas, particularly in Xiengkhouang plateau.

### Highland

Development of appropriate credit schemes and investment incentives to generate income and create employment for highland farmers as an alternative to shifting cultivation. Development of leguminous forage for integration into farm management and land conservation systems is also required.

Research on forage development in the mid-term should be adaptive and mainly on-farm. It should concentrate on developing grass/legumes, and fodder trees integrated into different farming systems and conservation systems for sustainable production.

- Introduction and selection of grasses, legumes and fodder trees for different agro-ecological zones and farming systems.
- For the lowland area, cut-and-carry backyard fodder is considered to be suitable for smallholders, and pasture development for some commercial ranching.
- For the plateau area, there is a need to introduce selected acid-tolerant cultivars.

## Discussion

Research is needed to generate knowledge on how to overcome technical, economic and social constraints to increased agricultural performance, and contribute to poverty alleviation. Given the socio-economic conditions, skilled manpower and farming systems found in the Lao PDR, adaptive research will play an important role. Adaptive research programmes should reflect market realities, farmers' needs, and the diversity of agro-ecological (bio-physical and socio-economic) environments in the country.

- Adaptive research in livestock production systems in the area of pastures, better use of crop by-products, pig and poultry raising, and aquaculture (indigenous fish) will be initiated in collaboration with research on crops and forestry.
- A farming systems approach, and interdisciplinary approach to research and development, will be used on all on-farm adaptive research to develop more sustainable farming systems applicable to local conditions without degrading the resource base.
- Agroforestry research will be undertaken to address problems of shifting cultivation on sloping land areas. It will design and test technologies in which both fruit-bearing and wood-producing trees are combined on fields simultaneously with field livestock and/or fisheries.

The relationship between research and extension systems will be strengthened since the two-way flow of information between research and extension is essential to the relationship. This will be done by utilising agricultural college faculty members as resources in research, providing students (future researchers and extension agents) with an understanding of the problem-solving approach to agricultural systems, and utilising researchers as lecturers in agricultural colleges.

Collaborative linkages will be encouraged with international research centres and other national research programmes for the exchange of information on appropriate component technologies and systems, which are potentially helpful in the attainment of national development goals and objectives. These linkages will also be encouraged with the private sector in research and development activities, when there are mutual interests relating to testing new technologies, training of personnel, demonstration of technologies, and establishment of information exchanges such as bulletins, newsletters or technical packages.

Research should emphasis improvements in productivity with the long-term sustainability of natural resources, the generation of income and employment, and should reflect an aspiration to distribute the benefits of the development to less advantaged farm families and to women.

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# Research priorities for improving animal agriculture by agro-ecological zone in Papua New Guinea

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## Abstract

The agricultural sector, within which livestock has a major role, is important in Papua New Guinea. Total meat consumption is increasing at a rate of 5% annually. The agro-ecological zones fall into seven categories: lowlands, pre-montane, lower montane, mid-montane, upper montane, subalpine and alpine. Dairy and beef cattle production, and pig and poultry production are especially important, while goat and sheep production are less so. Research issues include forage production and utilisation, soil–pasture nutrient deficiencies, effective utilisation of local feeds, appropriate feeding systems and improved animal health. Human resource development and considerable resource inputs are necessary for strengthening the national agricultural system .

## Introduction

Papua New Guinea (PNG) is an island state of the south-west Pacific region (SWP). It lies between latitudes 5°N and 23°S, has a population of approximately 4 million people and occupies a land area of 462,243 km<sup>2</sup>. It is the largest of the developing countries in the region with 85% of the land area and 70% of the population.

The agricultural sector will continue to be an important sector to the country for sometime yet despite recent rapid development of its mineral and petroleum resources and their significant contribution to the economy. This has been well appreciated and acknowledged by the Government of Papua New Guinea, however, the sector is open to international factors and has to be protected when necessary.

The government has in place some mechanisms to effect some form of protection and these include:

- establishment of stabilisation funds for export tree crops, e.g. copra, coffee and oil palm
- encouragement of downstream processing of agricultural commodities
- imposition (strategic) of import bans/tariffs/quotas on certain agricultural imports, e.g. poultry, beef and pork meat
- reduction of tariffs on certain agricultural inputs, e.g. live bulls and semen.

Some degree of progress has been made in aspects of domestic agricultural productivity, e.g. increased domestic production in vegetables and fruits, self-sufficiency in sugar, poultry meat (95%), eggs (100%) and pork (85%) have been achieved since these initiatives were applied. However, the growth in the agricultural sector output has been below the population growth since 1980

(ANZDEC 1994). The main factors contributing to the decline are 1) heavy dependence on tree crops such as copra, cocoa and oil palm which have experienced sharp declines in world tree-crop commodity prices since the 1980s, 2) lack of clear and creative policies and strategies, and 3) ineffective organisation and support to research and extension services.

The agricultural export sector has been seen, and is supported as the major thrust in PNG agricultural development. This is largely because the 85% of the population which live in the rural areas, the major participants in this sector, rely on this as their source of income. This sentiment has been endorsed by numerous consultants who have been brought in to review the agricultural system in the country (e.g. ANZDEC 1994). Thus the food security sector has been somewhat pushed aside for some time, with the livestock sector being the most neglected. In the last 10 years, the sector was basically without direction, with no bureaucratic machinery to oversee the implementation of whatever little livestock development strategies that were drawn up.

Whatever the reasons for the neglect, this is not justifiable because:

- total meat consumption rate in PNG is increasing by about 5% per annum commensurate with a population growth rate of 2% per annum
- the high rate of malnutrition is due to protein deficiency in the diets
- over US\$ 73.2 million is spent annually on meat imports
- over 500,000 ha under natural grasslands is potentially available for pastoral farming
- past research and development efforts are incomplete.

With such a depressing state of affairs in the livestock sector, there is a pressing need to review and refine past research and development activities, and develop new ones which should take the country beyond the year 2000. Obviously, setting clear and creative policy guidelines should set the pace with immediate injection of major resources.

This paper is intended to highlight various livestock research and development activities, constraints and the areas where research is most needed. The capacity of the PNG livestock research system and where assistance will be most required will be also discussed.

## **Natural resources in Papua New Guinea**

The natural resources which will be discussed in this paper are those that have significant direct or indirect implications on livestock agriculture in PNG.

### **Land**

Of the 462,243 km<sup>2</sup> total land area, a high proportion is mountainous and limits its sustainable use, especially on the main island where a mountainous spine runs through the centre. These mountains are catchment areas for the country's major river systems. Where these rivers empty into the sea, swamps and marshlands predominate. These are especially found in the western and northern parts of the country.

In spite of this, there are vast areas which are extremely fertile and have been used or are being targeted for intensive agricultural activities. However, few of these have been subjected to detailed investigations of their suitability for various agricultural purposes.

## Forest

PNG is one of the few countries which still has much of its rain forest intact. However, the rate at which its forest has been harvested for export in recent times has become a concern to both national and international environmentalists. Similar concerns have been raised when large areas have been cleared to make way for estate agriculture, particularly, the oil palm, cocoa and rubber estates. Clearing for grazing purposes was practised in the 1960s and 1970s but has since been considered inappropriate and a waste of natural resources.

## Marine resources

Like the forest, most of the marine resources are intact but with a vast coastline (200 nautical mile exclusive zone) and limited resources to maintain constant surveillance of these waters, illegal fishing by foreign fishing companies has been a major concern. Several companies have been licensed to fish and, more recently, to process their catches on shore in PNG. Thus one fish cannery has been commissioned and a further three are on the drawing board for development. PNG imports and uses about 1600 t of fish meal every year in stock rations. How much fish meal will be produced by these canneries is not known, however, there will be substantial quantity of this product produced locally and it will be available for use in livestock production.

## Natural grasslands

Natural grasslands are a dominant feature of PNG geography, and are mostly found in the southern, northern and highland parts of the country. These grasslands are dominated by fire climax grass species such as *Imperata cylindrica*, *Themeda australis*, *Pennisetum polystachyon*, *Capillipedium* and *Arundinella* species. Of about 5 million ha, about 150,000 ha are being grazed but there are about 500,000 ha recognised as an important resource available for low cost feeding of livestock (Galgal et al 1993).

## Food (feed) crops

Traditionally, PNG agriculture is based on root/tuber crops, especially sweet potato, (*Ipomea batatas*), yams (*Dioscorea* sp), taro (*Colocasia* sp) and sago (*Metroxylon* sp) and in some areas, banana (*Musa* sp). In the highlands (the most populated area) the agricultural system is based on sweet potato while in the lowlands it is usually a number of these crops, although many are produced seasonally (Table 1).

**Table 1.** Some traditional (potential) energy and protein food crops used in livestock production.

| Species                           | Common name   | As staple in                             |
|-----------------------------------|---------------|------------------------------------------|
| Energy source                     |               |                                          |
| <i>Colocasia</i> sp               | Taro true     | Morobe and Oro provinces                 |
| <i>Cocos nucifera</i>             | Coconut       |                                          |
| <i>Discoria</i> sp                | Yam           | Sepik and Milne Bay provinces            |
| <i>Ipomea batatas</i>             | Sweet potato  | All highland provinces                   |
| <i>Saccharum officiarum</i>       | Sugar-cane    |                                          |
| <i>Musa</i> sp                    | Banana        | Morobe and New Britain provinces         |
| <i>Metroxylon</i> sp              | Sago          | Sepik, Gulf, Western and Manus provinces |
| Protein sources                   |               |                                          |
| <i>Psophocarpus tetranoglobus</i> | Wingbean      |                                          |
| <i>Phaseolus lacnatus</i>         | Lima bean     |                                          |
| <i>Phaseolus seaberaulus</i>      | Wild mungbean |                                          |

The recent introduction of new crop species, e.g. maize, cassava, onions, pawpaws, melons, taro, kongkong (*Xanthosoma* sp) etc has expanded the food and animal feed basket.

## Animals

Historically, PNG was devoid of ruminant animals and livestock agriculture was limited to pigs and chickens, with pigs being by far the most important animal. However, these animals are less frequently slaughtered for consumption. Most of the animal protein sources are derived from the grasslands, forest and jungles in the form of wild game animals. These are predominantly wild game birds (e.g. flying foxes, cassowaries/guria pigeons) and marsupials (e.g. wallabies, cuscus and bandicoots). Despite recent introduction and development of other animal species, e.g. cattle, sheep and goats, wild game animals continue to be harvested constantly with greater efficiency with the use of modern technologies. As a result some wild game animal populations are declining at an alarming rate, e.g. cassowaries. Relatively little is known about their population and how much more pressure they are able to withstand before they become extinct.

## Land use factors

### Land tenure

There are two forms of land tenure in PNG: the alienated and the customary land. The alienated land is the land acquired by the State for its own use or to make available to other estate developers. This only accounts for about 3% of the total land area; the rest (97%) is owned basically by the people. The availability of this type of land for commercial agriculture has been constrained because of changing views about its importance and value by its owners.

It is interesting to note that clan or individuals do not own one large portion of land but, rather, several small portions scattered throughout the boundary of the tribe or village land. This has been an underlying factor hampering any attempts (by the clan or individuals) to expand their agricultural ventures.

## Soil fertility

The soils in PNG vary from highly leachable sandy loams to extremely fertile clays and clay loams formed from past volcanic or river activities. Little is known about the overall fertility status of the soils throughout the country. It is only recently that attempts have been made to pursue this mammoth task, especially. in areas considered to have potential for agricultural development.

Quite a lot of arable land is waterlogged throughout the year. Some has been drained for agricultural use, e.g. in Whagi Walley. Recent surveys suggest a number of these areas are suitable for paddy rice development.

## Agro-ecological zones

There is a distinct difference in climatic and soil factors and vegetation throughout the country. At least three zonation system have so far been described. The first is based on vegetation (Johns 1977; Johns 1982) and the second on temperature differences (MacAlpine and Keig 1983). The third is a compromise between these two systems (Gurnah 1992) which advocates subzoning so as to fit more closely with distribution of crops in the country (Table 2). Although the third system is a simplification of what is a complex situation, which involves very rugged country with an incompletely studied micro-climate, it provides a clearer picture of the suitability of various ecological zones for different agricultural activities.

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**Table 2.** *Agroclimatic zones of Papua new Guinea.*

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### Zone 1: Lowlands

This zone consists of areas which lie at 0–600 m above sea level (m asl) with annual rainfall ranging between 1000 and 10,000 mm. These are relatively hot areas, with mean annual maximum and minimum temperatures of 32 and 23°C, respectively. There is little seasonal variation in either temperature or relative humidity (100% at dawn to 70% in mid-afternoon). This zone consist of four subzones with varying distribution and potential for different crops (Table 2).

### Zone 2: Pre-montane

This zone lies at 600–1500 m asl with average annual rainfall of 1500–5000 mm. Temperatures range from 18 to 29°C. The distinctive climatic factor is the greater variation in the diurnal temperature compared to the Zone 1. Farming is limited because most of the land is too steep and rugged, though many different crops can be cultivated (Table 2).

### Zone 3: Lower montane

This zone represents altitudes of 1500–1800 m asl with maximum and minimum temperatures of 25 and 12–13°C, respectively. Ground frosts are common in this zone, with increasing frequency as the altitude increases. This is the most densely populated and heavily cultivated area in the country.

## Zone 4: Mid-montane

This zone is found at altitudes of 1800–2700 m asl, its upper limit being the cut-off point in cultivation due to frequent frost. Frequent famines occur in this zone because of frost damage to crops. Rainfall is over 2000 mm and the maximum and minimum temperatures are 22 and 11°C, respectively, with little seasonal variation.

## Zone 5: Upper montane; Zone 6: Subalpine; Zone 7: Alpine

These three zones are of no agricultural significance since no cropping can be done due to the regular frost.

There is still room to link climate to soils and to construct an agro-ecological zoning system to match that of FAO (1978).

## Production systems and constraints

The animal production systems in PNG are primarily tuned to boost local production to meet local demand for meat. This section attempts to highlight the production system employed for each animal species and the constraints associated with their production.

### Cattle

The first cattle, mainly dairy breeds, were introduced into PNG in the late 19th century. These were used primarily for weed control in the plantation industry and little attention was given to animal husbandry or pasture improvement. Promotion and funding from local and international aid agencies in the 1960s and 1970s saw an increase in cattle population which peaked at 152,000 in 1976 but declined sharply to 90,000 in 1993.

Besides government controlled nucleus cattle herds, large ranches and smallholder projects were equally promoted. On the mainland and a number of large outer islands large ranches were developed based on *Imperata*-dominated grasslands.

Grazing cattle under coconut was also commonly practised in the coastal and outer island areas, mainly as an attempt to control weeds. The cattle were set stocked, often at higher stocking rates resulting in serious weed infestation problems.

Smallholder cattle development initiatives were not as successful as hoped. This situation can be attributed to a number of factors and have been summarised by Shelton et al (1993) as:

- Indigenous smallholders had no traditional experience with cattle, thus their standards of animal husbandry were low.
- Smallholders were introduced to commercial production too quickly, and at too large a scale.
- Brahman cattle, the main breed used, were sometimes difficult to control.
- Disputes over the ownership of the land interfered with running the projects.
- Many smallholders encountered serious soil nutrient deficiencies which affected both pasture growth and animal nutrition.

Incorporation of cattle or other ruminants into agricultural estate projects such as oil palm and rubber have been disappointing. Adoption of feedlotting and

supplementary feeding technology is slowly increasing and is expected to feature more in the future. This is primarily due to the availability of large volumes of agro by-products such as molasses, sugar-cane tops, oilpalm cake and copra meal. Use of tree legumes such as *Gliricidia sepium* and *Leucaena* sp in providing a protein supplement is being practised on a limited scale—a recent Australian Centre for International Agricultural Research-funded project attempts to explore the possibility of grazing leucaena on a sustainable basis.

The decline in cattle numbers from the peak of 1976 is a cause for concern. Some of the underlying issues which have contributed to this situation include:

- Lack of incentives for producers to adopt improved pasture technology and nutrition standards, thus resulting in low calving and offtake rates.
- Uncontrolled slaughter of breeding cows.
- Serious feral cattle problems and their killing on a large scale.
- Lack of adequate marketing infrastructure.
- No bureaucratic direction to co-ordinate livestock research and development in the last 10 years.
- Research outputs were not utilised immediately due to ineffective research–extension–farmer linkages.
- No follow-up research to fully explore earlier findings, thus most of the crucial problem areas remain unexplored.

## Goats and sheep

There are about 20,000 goats and 15,000 sheep in PNG. They are mostly reared by subsistence farmers as a source of meat and income. There has been an increasing interest in these animals and they are being reared in preference to cattle, largely because of their smaller size and requirement for less grazing area.

Most goats are grazed free range or are tethered and consume natural pasture, weeds or crop residues of variable quality. Shelter is often provided but in some instances, where dogs are not the problem, the animals are sheltered under the farmer's house. The husbandry standards are low resulting in poor reproductive and growth rates, however, there are relatively fewer problems with internal parasites (Manua 1993). This is because only a few animals (less than 10) are usually kept and they are rarely fenced in. Cut-and-carry feeding is seldom practised. In-breeding is relatively high as the offspring are not separated from their parents and farmers rarely seek to exchange their bucks.

Unlike goats, sheep are usually provided with shelter during the night and shepherded during the daytime. However, like the goats, they also suffer from low husbandry standards resulting in poor reproductive and growth rates. Since the mid-1970s the government has tried to develop a sheep industry based on locally developed highlands halfbreeds (with New Zealand Government assistance) for the highlands and cooler areas in the lowlands. The results have been disappointing, largely due to the inability of the government-owned nucleus farm to cope with the demand.

Goats and sheep have enormous potential in village livestock farming systems, however there are several crucial factors which have affected their development in PNG. These include:

- slow adaptation of the highlands halfbreeds to the local environment
- lack of sufficient husbandry skills among farmers and extension workers
- poor quality pastures being used, leading to low reproductive and growth rates
- increase in homogeneity in the goat population as no new material has been introduced, and lack of an organised marketing system.

## Pigs

Because of their traditional significance, pigs are reared throughout the country. There are about four large commercial piggeries (over 500 sow units) which cater for urban markets. Approximately 1.2 million pigs are reared by individual households for their own use.

Improvement of the native pig was initiated in the 1940s. Breeds such as Berkshire and Saddleback were introduced and promoted on a nation-wide scale. As a result, what now may be considered as a native pig has some blood of these breeds.

The majority of the village pigs are free ranged and consume a variety of residues from households besides scavenging the territory. In the highlands they are often tethered and brought to old gardens where they are left to dig old sweet potato patches. It is common practice to use pigs to "plough up" the land for the next crop.

Village pigs consume high fibre diets and produce small litters (mean of 6 piglets/litter). Their growth rates match those of exotic breeds up to 21 days of age, when the exotic breeds begin to outgrow the natives (Moat, unpublished data).

With growing urban areas, a number of peri-urban piggeries have been developed. These piggeries, usually with no more than 20 sow units, offer their pigs commercial diets often supplemented with household residues and crop wastes, specifically foods such as cassava, sweet potato and banana.

Improving village pig production has failed because 1) there is no cheaper alternative food source to household residues and free range, 2) villagers are reluctant to change to introduced systems and 3) there is no organised marketing system which would create a need to improve management and production.

## Poultry

The poultry industry in PNG can be categorised into three:

- village production
- peri-urban production
- commercial production.

The village poultry are usually free ranged and are either sheltered at night or allowed to roost in nearby trees or behind the houses. There are about 1.0–1.3 million of these birds. Traditionally, they were kept for prestige purposes but are now also reared for consumption. In the 1960s, new strains of dual-purpose birds such as the Australops and Rhode Island Reds were promoted nation-wide. Despite the introduction of these new strains, their performance is poor, largely because of lack of energy feed sources in village conditions (Bakau and Kolombus 1992).

The peri-urban production involves farmers living close to the urban centres. These farmers produce chickens to sell, fresh eggs or live birds in urban areas. A few are

also contracted by established poultry firms to produce birds for them. Stock feed, birds and extension service are provided by the company and the farmer provides the shed and labour—a net payment is made to the farmer after deductions.

Commercial poultry firms use modern production systems, and achieve comparable performance indicators to similar flocks in Australia. The imposition of a ceiling on retail price especially challenged the companies to improve their efficiency and thus to achieve performance indicators worthy of overseas poultry companies. However, there are many problems these companies face, including severe heat stress which affects feed intakes, disease outbreaks and contamination of stock feed.

The problems affecting peri-urban poultry production are due to management factors which affect growth rates, feed conversion ratios and profitability. Feed mills are located in two areas of the country and therefore those producers in distant places are constrained by high feed cost and the feeds do not last long before they become mouldy.

## **Research issues and research and development priorities**

Livestock research in PNG is relatively young, being some 30 years old.

Factors associated with genotype–environment interaction, utilisation of locally available feed resources and animal health still dominate these research efforts. However, these efforts are exploratory in nature with still many ‘loose ends’.

### **Ruminant livestock**

Of the grazing animals, the problems associated with beef cattle have received the most attention. For instance, it has been shown that the growth and reproductive rates of the *Bos indicus* breeds are superior to those of the *Bos taurus* genotypes (Holmes et al 1980). The rainfall pattern of the local environment has a marked influence on the growth of pasture and hence on the nutrition of the animals. Supplementary feeding using copra meal, millrun and oil palm kernel cake greatly improved growth rate: as high as 0.93 kg gain per day, compared with 0.2 kg gain per day in native pastures were achieved (Galgal et al 1993). The problems of leucaena toxicity in ruminants also received some attention. This problem has since been solved with the introduction of mimosine- and DHP-degrading rumen microbes (*Synergistes joesii*).

However, despite, these efforts there remain many areas which require investigation to tune the industry to the changing husbandry and cultural practices. The areas which require some immediate research include:

- toxicity problems associated with signal grass (*Bracharia decumbens*) based pastures
- soil-pasture nutrient deficiencies in ruminants
- agronomic and nutritive value of native grasses and legumes
- utilisation of fodder tree legumes
- improvement of local breeds.

Little is known about goats, but in sheep some efforts have been made to study their performance on different pastures and under different management systems. The problems affecting small ruminants are very similar to those of the cattle. However, these problems differ slightly in that management and health (internal parasites) factors are the major problems. Adaptive investigations exploring these areas and some breed improvement programmes would greatly enhance their production performance. Improving the breeds to yield high proportions of multiple births is an area which needs to be pursued. An area which requires similar attention is the dairy goat. Introduction and testing them in local conditions is certainly overdue as they are suitable for smallholder production.

Thus, there is a need for an holistic approach to the development of improved pastures in PNG to ensure the incentive for this activity is not limited by other factors. Smallholders with only recent experience in using pastures farming require simple, robust and sustainable systems. Continuing breed improvement, evaluation of native pastures, introduction and evaluation of new pastures and soil fertility testing should continue to be research priorities. Closely related to these is the need to develop management strategies that will combat the massive weed infestation problems. Because of their demonstrated productivity, persistence and versatility, some attention has to be paid to the use of tree legumes such as leucaena and gliricidia.

The problem of poor adoption of improved pastures by the producers is a concern. Research workers must work closely with the extension officers and innovative farmers to ensure that the benefit is accepted and not just presented in journals.

The low number of nationals in animal research in general and their lack of expertise are serious limitations to further development. Direct technical and training assistance will improve local competence. Similarly, to foster the standing of livestock research, the research institutions have to be separated, and charged with a specific research agenda based on either species or climatic zones.

Development of an organised marketing system is important to encourage increased production.

## **Monogastrics**

The monogastric research programmes were undertaken by two research institutions, Labu Animal Husbandry Research Centre (then the Poultry Research Centre) and the Tropical Pig Breeding and Research Centre based in Goroka. The latter has since been closed down.

As in ruminants, most emphases were given to introduction, testing and development of new breeds and strains. Evaluation of locally available feed sources, nutritional requirements in PNG conditions and management factors were also addressed. Chemical and biological monitoring of stock feed quality was an important activity in these centres.

For poultry, most of the research findings were adopted and utilised by the industry. The pig research findings however, have not been well adopted. The breeding programme based on native pigs was prematurely disrupted due to withdrawal of research workers.

There are, however, many areas which still require investigation. Many of these would involve expansion of past research efforts to further investigate the influence of heat stress on, for instance, utilisation of amino acids in relation to metabolisable

energy. With feed being the major input, developing and devising simple and cheap feed should continue to be given priority. There are certainly other breeds, types or strains of monogastrics (e.g. Japanese quails) available in other countries which should be introduced and tested. Husbandry and animal welfare factors have also to be considered.

An area which could boost village chicken production is using choice feeding systems based on farmers producing one half of the ration (energy). Traditionally, PNG farmers share their food gardens with animals. With increasing pressure to produce their own meat rather than hunting for it, producing food specifically for the animals would ease pressure on family food gardens.

## **Native livestock**

No work has been done on native animals though they have been constantly consumed. Several can be tamed and farmed on a sustainable basis. These livestock include cassowaries, guria pigeon (world's largest pigeon), bandicoots and wallabies. The people know what they taste like and therefore there would be no need to launch a promotional campaign.

An understanding of their behaviour, physiology and nutrition would assist in exploiting these livestock.

## **Other livestock**

Besides the above livestock, there are others which can have some impact on livestock development in this country. Animals such as guinea pigs and rabbits have attracted most interest lately. Rabbits, particularly, could become a major industry for smallholders. Current fear on the potential threat to the environment needs to be researched. Their production using low cost feed should be a priority and their health and disease status should also be determined.

## **National research capacity and resource requirements**

Closing down the tropical pig breeding centre and shifting activities from the Beef Cattle Research Centre to a multiplication centre has left the burden of livestock research to only one research centre, the Labu Animal Husbandry Research Centre. The National Veterinary Laboratory and the Chemistry Laboratory provide the back-up services in laboratory analysis. Certainly, PNG livestock research capacity is too small and needs to be expanded. But this would require the injection of massive resources in areas such as improving the number and competence of the manpower and strengthening the existing research institutions. The Beef Cattle Research Centre's activities should be refocused to research. Establishing one more institution whose mission is to undertake basic livestock research should also be considered.

From years of neglect, the research equipment and facilities are inadequate and require upgrading. This view has been well supported by ANZDEC's 1994 review of the national research system. There are several international collaborative projects in the pipeline. These include the Australian Centre for International Agricultural Research-funded project on leuceana, and FAO-sponsored project on germplasm for native pastures. Clearly, there is a greater demand for international collaboration but given the national constraints, meeting the expectations of such programmes will be a difficult task.

# Conclusion

Livestock production systems in PNG need to be properly addressed and to do this, requires considerable research input. With the present state of neglect, the sector overall will lag behind the population growth rate and PNG will continue to foot a massive import bill. These will be avoided only when the sector (including its research institutions) is given the sense of belonging by injecting massive resources.

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# Research priorities for improving animal agriculture by agro-ecological zone in Fiji

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## Introduction

The livestock industry in Fiji is based upon chicken, beef, dairy, pork and goat production; ducks and the fledgling sheep industry play a minor role. This paper will describe the environment in which the industry operates including the physical environment, the available resources and an overall view of the agricultural sector. Constraints to production (nutritional, health and genetic) are also identified. Researchable issues are outlined and the current livestock research facilities and programmes briefly highlighted.

## The available natural resources

The Fiji archipelago consists of more than 300 islands with a total land area of 1,823,360 ha lying between latitudes 15°S and 22°S, and longitudes 174°E and 177°W. Of the total land area 87% is made up of the two main islands of Viti Levu and Vanua Levu.

## Topography, climate and soil resources

### Topography

The largest island, Viti Levu, has an area of 1,038,849 ha (57% of the total land area) rising to a maximum elevation of 1315 m. Topographically the island is made up of steep mountainous country bisected by numerous streams and rivers which account for 67% of the total land area. A further 17% of the total land area consists of rolling and gently undulating hilly lands. Flat lands and coastal plains make up the balance (15%).

Vanua Levu is the second largest island of the Fiji group with an area of 553,485 ha (30% of total land area). Topographically the island has a long mountainous back bone rising to an elevation of 1033 m. Of the total land area 72% is steep and mountainous, 13% is rolling and gently undulating hilly land and 15% is flat.

### Climate

The major climatic influences on Fiji are the South-East Trade Winds, the proximity of the ocean which moderates ambient temperatures, and elevation which is responsible for a rain-shadow effect on the larger islands. The climate of Fiji has been classified into three broad groupings based on average rainfall, and length of dry season: the wet type, the dry type and the intermediate type. (Twyford and Wright 1965).

*The wet type.* The wet type is commonly experienced on the windward sides of the high islands and is characterised by a very weak dry season, a high annual rainfall of 2500 to 5000 mm and mean annual temperature of 25°C.

*The dry type.* The dry type is commonly experienced in the rain-shadow areas of the large islands, and is characterised by a distinct dry season (June–November) each year, an annual rainfall of 1400 to 2500 mm and a mean annual temperature of 25.5°C.

*The intermediate type.* The intermediate type is characterised by a moderate dry season (August–November), an annual rainfall of 2000 to 2800 mm and an annual average temperature of 25°C. This type of climate occurs in the transition zone between the wet and dry types and on the smaller islands whose elevation is not sufficient to be a major barrier to the flow of moisture laden air currents.

## **Soil types**

The soils of Fiji have been described in detail by Twyford and Wright (1965). They classified the soils into the following categories: recent soils formed from coastal sands and river alluvium, Nigrescent soils characterised by high base status and clays of a relatively high cation exchange capacity, Latosols and latosolic soils, red-yellow Podzolic and related soils derived from quartz rich parent materials, Gley soils, organic soils developed in areas where the water table lies at the surface for much of the year, and saline soils in the regularly inundated coastal flats.

The most fertile soils are those that are recently formed from alluvial soils. Though the majority of soils show responses to fertiliser application. Fertiliser use is irregular in most of the cropping industries, with the exception of the sugar, rice, ginger and vegetable industries, resulting in declining levels of soil fertility. In the case of the livestock industries the use of fertilisers is non-existent except on government research stations .

## **Land-use factors**

The land use capability classification used in Fiji classifies land on the basis of susceptibility to erosion, steepness of slope, liability to flooding, wetness or drought, salinity, depth of soil, soil texture, structure and fertility, stoniness and climate.

Under the classification system land in Fiji is classified into one of eight major classes. Classes 1–4 comprise land that is suitable for arable cultivation, classes 5–7 are not suitable for arable cultivation but suitable for pastoral or forestry use, and class 8 is suitable only for watershed protection purposes (LUS 1977).

## **Availability**

The ability to carry out farming is restricted by land availability. The large demand for land and the relative scarcity of good agricultural land currently limits the expansion of agriculture. The land use section of the Department of Agriculture has estimated that 23% of the total land area of Fiji is currently used for arable agriculture. The encroachment of cropping into areas of low natural fertility and the increased usage of steep slopes for both cropping and livestock rearing is of major concern.

## **Accessibility**

The problem of accessibility to markets is a major drawback for livestock farmers. The fertile coastal flat lands close to the main highways are largely used for

cropping, consequently livestock farming is restricted to the hillier interior areas of most islands. This isolation, combined with the small number of abattoir facilities, results in high transportation costs. On outer islands the problems of marketing agricultural produce (crop and livestock) are compounded by the high shipping charges and irregular shipping services.

## **Land tenure**

Of the total land area of Fiji, 15.8% is freehold, 11.2% is state land and 73% is held as native land (NAC 1992). Under the conditions of the Agricultural Landlord and Tenants Act (Government of Fiji 1985) the maximum term for leasing of native land is 30 years with 10 extensions subject to the approval of the Native Land Trust Board and the consent of the Native Landowners. Tenants whose leases are not renewed may claim compensation for any improvements made upon the land.

The ALTA in its current form is seen by many farmers as a disincentive to reinvestment of farm profits on the farm. This attitude is common in the dairy industry where farm profits are being invested off the farm to provide a secure future should leases not be renewed. As a result many farmers do not carry out necessary farm and pasture improvement work and rely heavily on supplementary feeding for production.

## **The population**

The 1986 population census placed the total population at 715,375. Of this 46% were Fijians and 53.7% were Indians, with the balance being made up of Chinese, Europeans, Rotumans, part Europeans and other Pacific islanders.

Of the Indian population, 273,088 (33% of total population) were Hindu, 56,001 (7.8% of total population) were Muslim and 378,452 were Christian (52.9% of total population). At the time of the census 61 % of the total population was based in rural areas, with 44% of all economically active people involved in agriculture(BOS 1988).

## **Crop production**

The crop sector of Fijian agriculture consists of three production systems. A semi-subsistence production system is based on rural dwellers/villagers who rely on the sale of crop surpluses to raise funds for essential expenditure; commercial producers for the local market (mainly market gardeners) and an industrial/export system based on a number of farmers who produce a small range of crops primarily for export. Of these the major crops are sugar and ginger.

## **Sugar**

The sugar industry has dominated the Fiji economy since 1882 with the opening of the first Colonial Sugar Refining Company mill. The mills have since been taken over by the locally owned Fiji Sugar Corporation. In 1993 total sugar revenue generated by the Fiji Sugar Corporation was US\$ 273 million (12% of GDP). This was produced from a total of 3,703,484 t of cane resulting in the production of 442,156 t of sugar and 129,000 t of molasses from a total of 22,656 farms covering a total of 73,890 ha (average farm size of 3.26 ha). The industry at present employs more than 100,000 persons (MAFF 1994). The sugar industry is located entirely in

the intermediate and dry climatic areas of the two main islands. Sugar-cane tops and bagasse, fibrous by-products of the sugar industry, are not extensively used for livestock feed, though molasses is commonly used especially on dairy farms.

## **Coconut**

The coconut industry, has declined in importance largely as a response to the low world market price for coconut oil. However, there is still a large area of land under coconuts (64,953 ha) that produced a total of 10,232.63 t of copra in 1993. Of the total copra production 60% was produced on the island of Vanua Levu, 0.04% was produced on the island of Viti Levu with the balance being produced on remote islands throughout the Fiji group. There are four copra mills at present in operation. The largest mill located in Vanua Levu processed 89.1% (8618 t) of the total copra produced during 1993. The other mills are located on small islands in the Lau Group (2 mills processing 5.4% of total copra production) and a fourth is located in the city of Lautoka, processing 5.5% of total production (MAFF 1994).

To maintain mill operations it was necessary to import 137 t of copra in 1994. Coconut meal is an important by-product of the industry and is used extensively by feed millers in compounding rations. However, the fall in local copra production has resulted in increased levels of meal imports (1039 t in 1994, AH&P 1995).

Since world copra prices plummeted in the 1970s there has been a move towards increasing cattle numbers on coconut estates to reduce weed control costs and provide a supplementary source of income.

## **Rice**

Investment in the rice industry has been considerable, with an estimated 2154 ha of land being irrigated to facilitate the expansion of the industry. This represents 28% of the total land area under cultivation (7728 ha). Despite this Fiji was only 40% self-sufficient in rice production in 1993. Average yield per hectare of rice in 1993 was 2.36 t. There are two main rice mills in operation at present, both located on the mainland of Viti Levu. There are a number of smaller mills scattered throughout the rice growing areas (MAFF 1994).

Rice bran, broken rice and rice pollard are commonly used for livestock feeds though quantities available are small. Rice straw is not widely used for feeding livestock.

## **Ginger**

The ginger industry is relatively new. During 1993 there were 998 ginger farmers farming a total area of 149 ha (average size of area under crop 0.15 ha). All ginger production is carried out in the wet zone of Viti Levu. Average yields per hectare of ginger were 12 t/ha for immature ginger and 56.9 t/ha for mature ginger in 1993 (MAFF 1994).

## **Root crops**

There are six root crops of importance grown in Fiji cultivated on a total land area of 8217 ha: dalo, *Colocassia esculentum* (1855 ha), yams, *Dioscorea* sp (783 ha), cassava, *Manihot utilissima* (1588 ha), kumala, *Ipomea batatas* (150 ha) and

yaqona, *Piper methysticum* (1738 ha). Of total root crop production it is estimated that 30% is grown for subsistence purposes (MAFF 1994).

## **Cocoa**

Cocoa production is carried out on 3543 ha by 2342 farmers. Of the total, 51.8% is cultivated on Vanua Levu and 42.6% is cultivated in the wet zone of Viti Levu. The balance is cultivated on outer islands.

Of the total area under cultivation only 1720 ha (48% of total area) is at present bearing though yields of dry beans per ha are low (0.09 t/ha) (MAFF 1993).

## **Pulses**

In 1993, 1070 ha of land were under cultivation with pulses by 4317 farmers. Almost all of this was produced on sugar-cane farms in the dry and intermediate areas of the two main islands.

## **Maize**

In 1993, 689 ha of maize were grown by 1725 farmers. Of this, 235 ha were harvested yielding 662 t. Local maize is used for both human and livestock consumption. Given maize imports of 83.7 t for 1994 it is apparent that local production is inadequate (AH&P 1995). Local feed millers who represent the major consumers of maize have indicated dissatisfaction with the locally produced maize due to its variable quality.

## **Vegetable production**

A wide variety of vegetables are cultivated for both the local and export markets. Those of major importance are water-melon, pumpkin, cucumber, egg plant, beans, Chinese cabbage, okra, chilli, tomatoes and English cabbage. Of the total area cultivated in 1993 (3458 ha) 1013 ha was harvested yielding 7785 t of vegetables. Of this, 0.4% was exported.

## **Peanuts**

In 1993, 126 ha of peanuts were planted by 920 farmers; 112 ha were harvested yielding 184 t of peanuts. Of the total area under peanut cultivation 89% is carried out in the drier areas of Viti Levu (73%) and Vanua Levu (16%) producing 99% of the total peanut harvest.

## **Animal resources**

The livestock industry in Fiji is based on five livestock species, namely cattle, pigs, goats, chicken, ducks and, more recently, sheep. Horses play an important role in the provision of transport and draft power in rural areas (see Table 1).

**Table 1.** *Livestock numbers in Fiji.*

|                   | Cattle <sup>2</sup> | Chicken <sup>1,2</sup> | Ducks <sup>1,2</sup> | Goats <sup>2</sup> | Horses <sup>2</sup> | Pigs <sup>2</sup> | Sheep <sup>3</sup> |
|-------------------|---------------------|------------------------|----------------------|--------------------|---------------------|-------------------|--------------------|
| Number            | 280,221             | 781,173                | 135,935              | 187,233            | 15,366              | 90,850            | 6171               |
| No. of farms      | 42,789              | 64,788                 | 17,784               | 24,027             | 18,766              | 14,609            | 22                 |
| Average herd size | 6.5                 | 12.05                  | 7.5                  | 7.8                | 0.8                 | 6.2               |                    |

Note: The majority of stock were held on government research stations.

1. These do not include stock on commercial pig and poultry farms.

Sources: NAS (1992)<sup>2</sup> and SHSP (1992)<sup>3</sup>.

## The dairy industry

The dairy industry in Fiji began in 1920 with the establishment of 20 returned servicemen's farms. The industry exists on three levels: subsistence, town supply and factory supply. Total dairy production for 1994 is estimated at 1579 t of milk fat equivalents (TMFE). Milk product imports, however, were 3392 TMFE (AH&P 1995).

### Subsistence production

The subsistence sector consists of a large number of small holdings each with a small number of cows (house cows). Cows are milked for home consumption; surplus milk may be processed into ghee, some of which may be sold. Estimated production from this sector in 1994 was 970 TMFE (61.4% of total production) (AH&P 1995).

### Town supply

Town supply farmers are those who supply fresh milk directly to consumers. This may be done by the farmer himself or through middlemen (milk vendors). At present there are 24 town supply farmers who typically hold small herds, and supplied an estimated 60 TMFE (3.8% of total production) in 1994 (AH&P 1995).

### Factory supply

There are 156 dairy farmers supplying whole milk to the Rewa Co-operative Dairy Company (RCDC) which processes the milk and sells it locally as UHT or pasteurised milk. In 1994 these farmers produced a total of 416 TMFE (26.3% of national production). The sector is dominated by a group of 33 large farmers who produced more than 80% of all milk supplied to the factory in 1994. There are also a number of smaller farmers supplying whole milk to collection centres from which milk is collected daily by RCDC tankers.

In addition, there are eight cream farmers who supply cream to the company. A number of these farmers also operate small piggeries and feed the skimmed milk to their pigs. Total supply from this sector in 1994 was 133 TMFE (8.4% of total) (AH&P 1995).

The major technical constraints facing dairy farmers at present are low milk yields from pasture, long calving intervals and high calf mortalities (Samson 1993; Rutledge 1995).

## **The meat industry**

The meat industries in Fiji are present in a diverse array of structures which range from the highly organised and structured poultry industry to the unstructured goat industry. For this reason they will be dealt with separately .

### **The poultry industry**

*Poultry meat.* Of all meats marketed in Fiji, poultry has been the most consistent performer maintaining high and increasing levels of production. Between 1982 and 1992 poultry production increased at an average rate of 8.5% per annum. This may be in part due to the high level of tariff protection accorded the industry

The industry receives a high level of protection through import tariffs which are currently at 25%. The industry has maintained a 99% level of self-sufficiency since 1981 and exported poultry meats since 1987. National poultry meat production in 1994 reached a record 6570 t (AH&P 1995).

The poultry industry is dominated by two grower/processors, Padaraths and Crest Chicken Ltd. Padaraths produce approximately 20% of local production with 80% being produced by Crest. Both producers are vertically integrated producing their own feeds as well as growing and processing their own birds. The processed birds are widely distributed and offered for sale at a large number of outlets ranging from butcher shops and supermarkets to small shops. The production of ducks and other forms of poultry for sale is at present largely limited to backyard (semi-subsistence) production.

*Edible egg production.* Edible egg production in Fiji is dominated by 23 commercial producers who produced 3,640,000 dozens of eggs in 1994. Currently the local supply of edible eggs is sufficient to meet 99% of total consumption (AH&P 1995).

### **The pork industry**

Pork production in Fiji is dominated by a group of 10 large units which carry 74% of the total number of sows; the balance is held by 26 smaller farms, all of whom supply 5 butcher outlets. All slaughtering of pigs for retail is carried out through Fiji Meat Industry Board (FMIB) abattoirs. Over the past decade pork production has risen by 5.5% to 832 t of carcass in 1994, though its percentage share of the local market remains small (4.2% in 1994) (AH&P 1995).

At present the pork market is dominated by the hotel (tourist) trade which takes approximately 64% of total production. Of the balance 16% is sold through retail outlets (butchers) with the remaining 20% being sold at the farm gate.

The structure of the industry, whilst not being conducive to expansion, has provided producers with a relatively stable market structure. The industry has also benefited from relatively high levels of tariff protection.

### **The goat industry**

Number of goats slaughtered through registered abattoirs remains low, although estimates of total production (758 t in 1994) are high (includes estimates of farm gate sales). In the period 1984 to 1994 the total number of goats slaughtered through registered abattoirs increased by 193% from 358 to 1092 (the majority of which were culled does). Over the same period estimated local production

increased by 27%. At present goat meat production holds only a small percentage of the total meat market share (4.2% in 1994) (AH&P 1995).

The structure of the goat industry is characterised by a large number of producers each producing relatively few goats. Figures from the 1991 agricultural census indicate that at that time there were some 24,027 farmers rearing a total of 187,235 goats (about 7.8 goats per farm) (NAC 1992). At present it is estimated that some 97% of local goat production does not pass through the abattoirs but is sold on the hoof either at the farm gate by the farmer or through middlemen.

The demand for goat meat is seasonal—peak demand occurs at Christmas, Easter and other public holidays. The price premium received by goat farmers for sales of live bucks may go as high as US\$ 3.50–4.00 per kg live weight during these periods. Consequently there is little incentive for farmers to sell their animals through butcher outlets.

**The beef industry**

Between 1983 and 1994 total carcass beef production fell by 1092 t (approximately 3% p.a.) to 2305 t, and the total number of animals killed in registered abattoirs fell by 3.8% to 9769. This decline has been associated with a 30% increase in the level of beef imports with the level of self-sufficiency falling to 57% in 1994 as compared to peak of 74% achieved in 1987.

The 1991 Agricultural Census (NAC 1992) indicated that there were some 280,221 cattle on 42,789 holdings. Types of cattle recorded included beef (19%), dairy (13%) working bullocks (18%) and non-commercial head (50%). Cattle enter the market from all sectors of the cattle population and are sold to butchers either directly by the farmers or through middlemen. Cattle must be slaughtered through a registered abattoir, and the meat certified as being fit for human consumption before the meat can be sold. Price setting is done by the butchers who dictate prices. Whilst there is some attempt at grading at the abattoir there is no grading done at the retail outlets. The relative contributions of various classes of cattle are presented in Table 2.

**Table 2.** *Relative contributions to total numbers and weights of various classes of cattle in Fiji.*

| Stock class               | Bulls | Working<br>bullocks | Steers | Cows | Heifers | Total |
|---------------------------|-------|---------------------|--------|------|---------|-------|
| Per cent of total numbers | 11    | 26                  | 42     | 18   | 3       | 100   |
| Per cent of total weights | 8     | 28                  | 35     | 10   | 19      | 100   |

Beef distribution is generally limited to the urban areas. Reasons for the restricted distribution include the fact that beef is sold chilled not frozen, religious taboos restricting the sale of beef by Hindu outlets, the high costs involved in transporting chilled beef back to rural areas for sale, and the urban concentrations of wealth

In an apparent reaction to the low prices offered by butchers, there is a movement by cattle owners away from the formal beef markets to the more lucrative and less troublesome live (farm gate) market. This represents a loss to the Fiji Meat Industry Board (FMIB) in terms of the hide and a public health risk through the consumption of uninspected meat.

The size of the farm-gate market is unknown although surveys indicate that at least three cattle are slaughtered outside abattoirs for every animal killed through a registered abattoir.

## Constraints to production

### Animal health

Fiji is in the enviable position of being free from all OIE list A diseases. Diseases recorded are presented below.

#### Cattle

Fiji has an on-going Brucellosis and Tuberculosis Eradication Campaign (BTEC) which aims to eradicate the diseases from the national herd. At present, reactor rate to the single intradermal skin test for TB is low (0.12% of 41,338 animals tested in 1994). Of 14,000 animals tested for Bovine Brucellosis in the past two years there have been no positive reactors to the complement fixation test (AH&P 1994; AH&P 1995).

Munro (1978) reported the presence of theileria in Fiji. However, there is little known about the epidemiology of the disease locally.

Helminthiasis of calves is of general concern especially in the dairy sector where high calf mortalities (up to 75% on individual farms) are common. However, it is generally accepted that the mortalities are a result of poor management.

Diseases of cattle diagnosed by the Veterinary Pathology Laboratory in 1993 were bacterial scours, coccidiosis, enteritis/pneumonia complex, liver abscessation (*Fusobacterium necrophorus*), *Escherichia coli* and bacteraemia/septicaemia. A national serology survey carried out in the same year found Infectious Bovine Rhinotracheitis and Parainfluenza 3 (AH&P 1994).

#### Small ruminants

The major health problem of small ruminants is that of gastro-intestinal parasitism which may cause high mortalities on farms. The problem is often exacerbated by a concurrent protein deficiency. The high frequency of drug usage (monthly drenching) may result in parasite resistance to drenches. Research has resulted in the development of a rotational grazing programme, and the use of medicated urea-molasses blocks that are effective in controlling parasites.

#### Pigs

There are few diseases of pigs of major concern locally. Pig diseases diagnosed by the Veterinary Pathology Laboratory in 1993 were pneumonia (beta haemolytic streptococcus), septicaemia (beta haemolytic streptococcus), bacteraemia (beta haemolytic streptococcus), enzootic pneumonia, pasteurellosis, pleurisy/pneumonia, *Fusobacterium necrophorus*, peritonitis, piglet scours (bacterial, post-weaning scours), *E. coli*, bacteraemia (*Staphylococcus aureus*), pyaemia (*Corynebacterium pyogenes*), *Metastrongylus apri* (lungworm), *Stephanurus dentatus* (kidney worm), starvation, hypoglycaemia, overlaying and sarcoptic mange (AH&P 1994).

A national serology survey carried out in 1993 found porcine parvovirus, *Leptospira* sp and *Brucella suis* (AH&P 1994) .

## **Poultry**

As is the case in other livestock there are relatively few diseases of poultry present in the country. Those detected in the Veterinary Pathology Laboratory in 1993 include *E. coli*, septicaemia, omphalitis, streptococcal infest, pasteurellosis, gangrenous dermatitis, egg peritonitis, infectious coryza (*Haemophilus gallinarum*), cage layer fatigue, cannibalism and feather pecking, *Mycoplasma gallisepticum* (CRD), *Mycoplasma synoviae* and heat stress (AH&P 1994).

Results of a national serology survey indicated that Infectious Bursal Disease, adenovirus, reovirus, avian encephalomyelitis and Pullorum disease may also be present (AH&P 1994).

## **Genetic composition of livestock**

The genetic composition of the local livestock population is seen by many as a major factor limiting production. This view is supported by the relatively few importations of genetic material carried out.

## **Dairy**

The Fiji dairy industry is based primarily upon the Friesian breed of cattle, although there are a few Jersey and zebu crossbreds. The recently established artificial insemination (AI) programme is aimed at upgrading the genetic composition of the local herds through the use of imported semen. However, the rate of progress is likely to be slow as there is only one full time AI technician available in the country.

Monitoring the benefits likely to accrue out of the programme is difficult due to the poor record keeping practised by farmers.

## **Beef**

At present the government maintains two stud herds (Brahman and Hereford) to supply breeding stock to farmers. In addition, there is a Santa Gertrudis stud herd owned by the Yaqara Pastoral Company and a small Belmont Red herd that is the property of the Yalavou Rural Development Board.

There have been very few importations of new genetic material in the recent past. However, the importation of 100 doses of Brahman semen, 40 doses of Hereford semen and 200 doses of Limousin semen in 1993 is expected to help in some small way to overcome this problem.

As with the dairy sector a major area of concern is the monitoring of the programme to allow the measurement of the benefits.

## **Pigs**

The pork industry is based largely on the use of three breeds, viz. the Duroc, Landrace and Large White. There has until recently been little genetic improvement in the national herd. At present genetic improvement is centred on a few large commercial farms that carry out their own AI programmes, and a limited

AI programme provided by MAFF. It is the present policy of MAFF to restrict its AI programme to the government research herd at the Koronivia Research Station and to sell improved progeny to farmers. Semen is imported fresh from Australia. Farmers who have been involved in AI are generally happy with the results in terms of carcass conformation and feed conversion efficiencies.

## **Poultry**

The broiler sector is at present based on the usage of synthetic hybrid stock imported from Australia and New Zealand. The commonly used broiler breeds are Cobb and Steggles.

The egg sector currently uses Hyline birds imported from New Zealand.

The subsistence poultry sector is based on the 'Junglee Murgee' (jungle fowl) or coloured birds. Currently all coloured birds are sold as Junglee. These fetch a price premium in the live sales market.

## **Goats**

The local goat industry was, until recently based on a large number of goat breeds. An FAO-funded goat project resulted in the development of Anglo-Nubian crossbred goats which are now extensively used for meat production on commercial goat farms. The characteristics of the breed have been described by Hussein et al (1983).

There has been little introduction of new genetic material into the country with the flocks established during the FAO goat project remaining as the prime source of improved genetic material for farmers.

## **Sheep**

The Fiji sheep industry is based on the use of a locally developed hair sheep. The breed is the result of cross breeding of Barbados Blackbelly, Poll Dorset, Corriedale, Border Leicester and Wiltshire Horn breeds of sheep and the selection of the offspring. The project began in 1980 with the importation of 37 Barbados Blackbelly sheep from America.

There has been no importation of new genetic material into the national flock since 1986.

## **Nutrition**

Nutrition is the single greatest factor limiting animal production in Fiji. In the case of non-ruminant industries (pork and poultry) the major portion of the feed requirements are imported either directly in the form of feed ingredients or indirectly in the form of wheat by-products from wheat imported for milling locally.

Levels of imports of the main feed ingredients in 1994 were coconut meal 1039.6 t, mill run 1351.6 t, and soya bean 3326.4 t. In addition, 76,576 t of wheat and 137 t of copra were imported for milling purposes with by-products such as mill run and copra meal being used in feed compounding (AH&P 1995).

## **Non-ruminant nutrition**

There are five feed mills currently preparing computer formulated least-cost rations for sale. However, many pig farmers feel that the costs of formulated rations are too high and use their own 'home mixes'. The mixes generally comprise mill mix, coconut meal (when available), fish meal, meat and bone meal and kitchen swill when available.

There is a need to evaluate locally available feeds for use in the feed milling industry. An evaluation of cassava chipping has indicated that it is possible to produce up to 10 t of dried cassava chips from a hectare of cassava. The use of cassava chips in pig diets has been successful (Teleni 1972), although this is not commonly done as cassava currently fetches a premium price as human food.

## **Ruminant nutrition**

Ruminant production in Fiji is still based largely on pastures. Little research has been carried out into the nutrition of ruminants other than a limited number of grazing and supplementation trials. Current management systems for dairy cows still rely to a large extent upon feed supplementation to increase production.

There have been a number of studies on the Fiji dairy industry all of which have invariably highlighted nutrition as the major factor restricting milk production (Rowe 1991; Ochetim 1992; Samson 1993). Typically milk yields from unsupplemented dairy cows grazing para grass (*Brachiaria mutica*) swards of average quality are around an average of 5–6 kg per cow per day (Ranacou 1986a). The low levels of production were thought to be due largely to the inability of cows to consume sufficient para grass to meet their feed requirements, the low protein levels of the pasture, and low calcium (Ca) and phosphorus (P) levels (Teleni and Rasousou 1985). Supplementation of cows with a molasses–coconut meal mixture at a rate of approximately 3 kg per head per day is sufficient to almost double daily milk yields. Trials comparing the milk production of cows grazing various pasture species have indicated that milk yields are higher on *Setaria* than para grass. Comparisons of milk production from cows grazing Koronivia grass (*Brachiaria humidicola*) and Batiki Blue grass (*Ischaemum indicum*) indicate that cows grazing Koronivia produced more milk than those grazing Batiki—8.1 and 7.0 kg of milk per cow per day, respectively (Ranacou 1986c).

Long calving intervals (approximately 18 months) (Samson 1993) and high calf mortality (around 50%) (Thomson 1973) are commonly attributed to poor nutrition (McIntyre and Singh 1971; Samson 1993; Rutledge 1995) and gastro-intestinal parasites (Teleni 1974).

## **Beef cattle nutrition**

The majority of beef farms are located in the dry areas and as such are subject to seasonal variation in pasture production. The major pasture species are Nadi Blue (*Dicanthium caricosum*) and Mission (*Pennisetum polystachyon*) grass which produce 18 and 39%, respectively, of their dry matter during the dry season (Partridge 1979a). Stock grazing these pastures commonly experience marked reductions in liveweight gains over the dry season with compensatory growth occurring in the next rainy season (Partridge et al 1982). There has been little usage of supplementary feeds in beef herds despite demonstrated advantages from the feeding of a urea–molasses lick.

## Mineral nutrition

Surveys of cattle have indicated that many of the beef and dairy cattle in the country were deficient in phosphorous and that blood copper (Cu) levels were low despite adequate herbage copper levels indicating an imbalance in the Cu/Mo/SO<sub>4</sub> complex (Ohman 1952; Newman 1970; Singh et al 1980).

Potter and Sparrow (1973) in a survey of bone P and Ca of animals slaughtered through abattoirs indicated that bone P levels were 25% below normal whilst Ca levels were 50% below normal.

A phosphorus deficiency was suspected to be the cause of lambs being born on Makogai and Nawaicoba with bowed front legs. This has been overcome by feeding coconut meal as a supplement. A growth response to cobalt supplementation (as a single injection of cyanocobalamin) at Nawaicoba is thought to indicate a slight cobalt deficiency in that area (Baker 1970).

## Pastures

At the time of the latest agricultural census there was a total of 173,406 ha of land under pastures on 23,607 farms (average 7.35 ha/farm). Of these, 3.5% were improved exotic pastures, 24.5% were improved native pastures with the balance being unimproved native pastures (72%). Of the total area under pasture 17.2% was found in the wet zone of Viti Levu (Central Division). The bulk (64.5%) of the pasture is in the dry zone of Viti Levu.

The dominant pasture species in use in Fiji vary according to climatic region. In the dry zone the major pasture species are Nadi Blue (*D. caricosum*) and Mission (*P. polystachon*). In the intermediate zone the major pasture species is Batiki Blue grass (*I. indicum*), while in the wet areas the major pasture species are para grass (*B. mutica*) and Batiki Blue grass, although setaria (*Setaria sphacelata*) is gaining in popularity. Levels of legumes in the pastures are low. In most cases it is restricted to naturally occurring hetero (*Desmodium heterophyllum*). There have been a number of attempts to introduce legumes (*Centrosema pubescens*, *Macroptilium atropurpureum* and *Peuraria phaseoloides*) into pastures but this has often been unsuccessful due to poor grazing management.

High levels of weed infestation are a major problem facing livestock farmers. Common weeds include guava (*Psidium guajava*), broom weed (*Sida acuta*), Koster's curse (*Climeda acuta*), hibiscus burr (*Urena lobata*), Japanese tea (*Cassia mimisoides*), kaumoce (*Cassia tora*), rattlepod (*Crotalaria striata*), prickly solanum (*Solanum torvum*), lantana (*Lantana camara*), navua sedge (*Cyperus aromaticus*), mintweed (*Hyptis pectinata*) and drala (*Vitex triflora*).

There has been extensive research carried out on pasture nutrition and grass and legume evaluation. These studies included the stocking rate trials of Parker (1977) and Partridge (1979b, 1986), and a number of fertiliser response trials (Partridge 1973) that measured responses to nitrogen, phosphorus, potassium and sulphur (N, P, K and S). The results of the response trials for para, Batiki and Nadi Blue grasses have been reviewed by Ranacou (1986a, 1986b, 1986c).

## Researchable issues

Animal agriculture has received much attention in line with the recommendations of the ISNAR (International service for National Agricultural Research) review of

agricultural research in Fiji (ISNAR 1985). The reviewer identified nutrition as the major factor limiting animal production in Fiji and recommended that the following areas be researched:

- The evaluation of species of grass and legumes including the shrubby legumes for specific areas.
- Studies on the nutrient requirements of these species in various combinations in pasture situation: fertiliser use in relation to yield and cost.
- Pasture management studies involving stocking rates and grazing patterns.
- Weed control in these management systems
- These four subprojects are to be done as a part of a series, since they are closely interlinked. Nutritional deficiencies have been identified and need correction before some of the newer species of legume can be expected to grow.
- Studies of the effect of nutritive levels on the growth rates of beef cattle, growth rates and milk output of dairy breeds, and on the fertility of all classes of cattle.
- Continuation of studies on goat nutrition.
- Continuation of monitoring of pasture problems especially woody weeds in the Western Division and finding ways by which they can be controlled.
- Ecological studies on grasses and legumes to complement pasture development and management projects.

These issues are as current today as they were when they were first formulated. Additional researchable issues include:

- the epidemiology of theileriosis in Fiji
- studies into the causes of calf mortality
- breeding for parasite resistance in sheep and goats
- the use of nematophagous fungi to control nematode parasites
- the importance of nutrition in the alleviation of the pathogenic effects of nematode parasites
- research on the Fiji meat market
- the efficient use of fibrous crop by-products.

## **Current research**

The dairy industry research effort is now largely being directed by the newly formed Interim Dairy Industry Council which has made funds available for investigations into the control of milk curdling (heat instability). The problem is of concern to the Rewa Co-operative Dairy Company which at present runs the only milk processing plant in Fiji. The instability of milk is of concern to the company because of the precipitation of deposits on the steritherm during ultra-heat treatment of milk. Present investigations are aimed at investigating the role of protein nutrition in alleviating the problem.

## **Pastures**

Pastures remains a major area of research with on-going trials being carried out to investigate the nutrient requirements of the major pasture species.

## **Beef research**

Currently, beef research is involved in the evaluation of Limousin crossbred calves and the determination of beef dressing out percentages for the various classes of livestock slaughtered in the abattoirs.

## **Goat research**

The main emphasis of goat research at present is on continuing development of the local goat breed through a programme of selection and culling. In addition, research is being carried out to further evaluate the use of a rotational grazing system in conjunction with a medicated feed supplement.

## **Sheep research**

Sheep research is at present aimed at three aspects: the improvement of the local breed of sheep through a programme of selection and culling, the investigation of the parasite–nutrition interactions in sheep and the development of appropriate parasite control systems, and the selection of the locally developed sheep for parasite resistance on the basis of faecal egg counts.

# **Resource requirements**

## **Current limitations**

The major constraints to research are in the fields of Staff numbers and Staff Training.

## **Staffing**

At present the Livestock Research Programme is staffed by two senior research officers (SRO Livestock and SRO Pastures) and one research officer (RO wet zone pastures). These officers have six technical support staff. The most highly qualified member of the research team is the SRO (livestock) who holds a Master of Science degree and is responsible for dairy and pig research. The SRO (pastures) holds a graduate diploma and is responsible for research in the area of dry zone pastures. The research officer (pastures) holds a Bachelor of Agriculture degree. Their support staff all hold diplomas in tropical agriculture.

In addition to the research officers there are a number of commodity specialist officers (AO goats, AO beef and SAO sheep) who carry out research work while also being actively involved in livestock extension work in their respective commodities.

## **Research facilities**

The facilities available to the researchers at present are outlined in Table 3.

**Table 3.** *Research facilities in Fiji.*

| Commodity | Station   | Land area (ha) | Stock numbers | Facilities     | Established staff numbers |
|-----------|-----------|----------------|---------------|----------------|---------------------------|
| Dairy     | Koronivia | 68             | 110           | Step-up bail   | 3                         |
| Pigs      | Koronivia | 0.3            | 162           | 36-sow piggery | 1                         |
| Pastures  | Koronivia |                |               | Drying room    | 2                         |
| Goats     | Sigatoka  | 110            | 224           | 5 goat sheds   | 2                         |
|           | Seaqaqa   | 10             |               | 1 goat shed    | 1                         |
| Beef      | Sigatoka  | 140            | 200           | 1 cattle race  | 1                         |
|           |           | 200            | 135           | 1 cattle race  | 1                         |
| Sheep     | Dobuilevu | 28             | 175           | 1 sheep shed   | 1                         |
|           | Makogai   | 180            | 2595          | 2 sheep sheds  | 1                         |
|           | Nawaicoba | 120            | 1893          | 1 sheep shed   | 2                         |
|           | Wainigata | 80             | 612           | 1 sheep shed   | 1                         |
| Total     |           | 936            | 6540          |                | 16                        |

The infrastructure available on research stations is generally very basic consisting of an office and other associated buildings.

In addition, the researchers are able to make use of the services provided by the Veterinary Pathology Laboratory, Fiji Agricultural Chemistry Laboratory and the Central Agricultural Library which is located at the Fiji College of Agriculture near Suva.

The Veterinary Pathology Laboratory provides diagnostic services to the national livestock industry as a whole. It is capable of providing bacteriology, haematology, histopathology, parasitology and post mortem examinations. The laboratory has recently acquired the equipment necessary for ELISA techniques.

The Fiji Agricultural Chemistry Laboratory provides analytical services for the Agriculture Department and to the government as the government analyst. Soil, food and plant analyses are provided. At present the Animal Health and Production Division makes extensive use of the laboratory for the analysis of soil and plant analysis. The services are provided free of charge. In addition, the Soil and Crop Analysis Project is involved in mapping the soil resources of the country.

Analysis of feed samples is restricted mainly to Kjeldahl crude protein and proximate analysis; mineral analysis is also being carried out. The ability to carry out enzymatic analysis of forage digestibility is being developed.

The Central Agricultural Library is the repository for most of the publications owned by the Ministry. However, scientists have limited access to information. High costs of library services such as the CAB library search facilities also preclude their being used regularly.

## Resource requirements

### Library

There is a need for scientists to have access to libraries/information systems to allow them to be aware of work being done elsewhere and prevent unnecessary duplication of research. Similarly, access to information may provide answers that would reduce the amount of research that is necessary. The provision of CAB

abstracts on CD-ROM would facilitate literature searches and reduce time spent in obtaining information.

## **Computers**

Currently there are three computers in the livestock research stations located at Sigatoka Research Station (2) and Koronivia Research Station ( 1 ). On those stations that do not have access to computer equipment all records are maintained manually in registers. If there is any need for data analysis the records must be taken to a location where computers are available. Given the amount of data recorded (pedigree and production), data entry is often time consuming and ties up both computer and analyst time. There is an urgent requirement therefore for additional computing facilities. However, levels of computer literacy are generally low and an effective computer training programme is necessary.

## **Facilities**

As previously indicated the facilities available for research are at present basic. There are no facilities for carrying out pen studies with ruminants and hence the nutritional aspects of livestock production receive little in depth attention. The provision of drying ovens would alleviate many of the problems associated with pasture research.

The construction of a nutrition house with metabolism crates would facilitate the evaluation of the nutritive values of local pastures.

## **Staffing and staff training**

The ability of staff to design and carry out research is at present limited by their lack of knowledge and experience. At present all research officers and commodity specialists are expected to be experts in all areas of their commodity, e.g. the Sheep Officer is expected to be fully conversant with all aspects of sheep management including nutrition, breeding and health. There is also considerable overlap in the knowledge requirements of specialists/research officers. The knowledge required for dairy and beef nutrition overlaps as does that required the goat and sheep fields. The genetic aspects of all commodities could easily be catered for by a geneticist/biometrician.

Research planning and management is another area that is in need of reinforcement. The ability of many research staff to design and implement research programmes is at present limited, making unbalanced poorly designed trials common.

Postgraduate training of staff members at both the MSc and PhD level is expected to alleviate much of the problem through the discipline of formal trial design, execution and analysis. Areas of study would include pasture agronomy, pasture grazing trials and animal nutrition.

## **Existing international programmes**

At present international research co-operation in animal agriculture is limited to that with CSIRO of Australia under the aegis of the ACIAR. Research is currently aimed at the use of medicated feed supplements to control internal parasites of sheep and goats either alone or with the rotational grazing. Results to date have

been encouraging and it is hoped to expand this area of research to include the development of a programme for the selection small ruminants for resistance to nematode parasites.

## Conclusion

Agriculture in Fiji is limited by land availability, soil conditions, accessibility, topography and land tenure system. Crop production is of major importance in meeting the food needs of the nation and generating foreign exchange through exports. Consequently, arable agriculture is carried out on the best land. There is at present little use made of fibrous by-products for the feeding of ruminant livestock.

The livestock industries consist of well-organised non-ruminant industry based largely on the use of imported feeds, and ruminant industry that is generally restricted to marginal areas of land.

Fiji is fortunate to be free from most of the serious diseases of livestock, though poor nutrition constrains production of ruminants from pasture. Pasture quality is generally poor with little improved pasture and, weeds present a major problem. There has been little importation of new genetic material into the country until the recent establishment of the Artificial Insemination Programme.

Currently research is focused on production from pastures, and pasture research. There are on-going selection programmes aimed at improving the quality of livestock.

Pasture nutrition, grazing management and animal nutrition are identified as areas for further research. Parasite control in small ruminants using rotational grazing, medicated feed supplements, nematophagus fungi and nutritional supplements are additional areas. Research is also required on the efficient use of fibrous crop by-products and the meat market.

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# **Establishment of a native carabao gene pool**

## **Selection and acquisition of outstanding native carabaos**

### **Identification of the areas/location where pure native carabaos are located/concentrated**

Information from the Bureau of Agricultural Statistics (BAS), the Philippine Carabao Centre (PCC), and the Department of Agriculture (DA) as to the population and recent inventory of existing carabaos distributed among the different provinces/regions of the country will be used as benchmark information in the initial identification of possible sources of carabaos. Likewise, data from private carabao raisers will be used as additional information in locating pure native swamp buffaloes. Preferences will be prioritised on location where carabao ownership is from 3–7 head/raiser. A team from PCCs where good, large carabao populations exist will make the preliminary selection of outstanding swamp buffaloes. The evaluating team should at least be composed of a breeder/geneticist, a production/management specialist and a veterinarian.

### **Individual selection of outstanding male and female carabaos**

Actual selection/identification of the best male and female carabaos will not be rigid initially, as long as the animals are healthy and possess the distinct characteristics of the native carabao (Annex 1). It will be based primarily on body weights and conformation, hence animals which are heavier and with good conformation/condition (Annex 2) will be selected. Whenever possible, actual body weights and other measurements should be taken during the team's visit and selection process. In cases where it is difficult to acquire this data, estimates using other measurable traits such as heart girth (Annex 3), body length and wither height can be substituted.

As well as the above, other information that should be included in the individual data sheet are: age (through records, certificate of ownership etc or estimation through dentition, see Annex 4), where the animal was procured or acquired, health status/condition of the animal at the time of evaluation, presence of physical and/or genetic defects and degree of relationship with other animals within the herd.

Individual data sheets (Annex 5) of each selected carabao in the different PCC units will be pooled and analysed at the PCC headquarters. A team from the Division of Genetic Improvement Unit will be responsible for the final selection of outstanding male and female carabaos which will be pooled in CLSU.

The trait ratio technique will be employed in the final selection of the best animals pre-evaluated from the different areas/locations. All carabaos selected by the PCC units will be evaluated and ranked across locations based on computed weight ratios. Male and female carabaos belonging to the top 25 and 150 ranks will become the foundation stock of the nucleus herd of the pure swamp buffalo genepool. Further, they should be tested for TB, brucellosis and leptospirosis before being transported to the PCC at the CLSU.

Selection of female native carabaos will be by age groups category. First priority for selection and possible acquisition are those caracows with ages ranging from 4

to 7 years. They will be known as the "ready to breed group". Additional information for selecting them should include age at first calving and number of calves weaned. Next, are the group of cows/heifers belonging to the 2–3 year old category. Similarly, 4 to 7-year-old carabulls will be prioritised for selection and acquisition. Information on the number of calves produced by each bull will be considered. Bulls with ages between 2 to 3 years will be considered next. In cases where there is difficulty in establishing carabulls in the mentioned age groups, one-year-old intact males may be considered.

## **Acquisition and management of best male and female carabao**

Owners/raisers of outstanding carabaos will be offered premium prices—higher than prevailing cost but within the ceiling approved by government accounting and auditing procedures. In cases where in spite of the higher valuation of the selected stocks, owners/raisers opt to keep their carabaos, then the next animals in rank will be considered.

Carabaos selected from the different locations by the concerned PCC units will be temporarily housed and reared in their respective centres until final selection by the PCC-OED Genetic Improvement Team has been completed. All carabaos selected will be pooled at PCC-CLSU where they will be afforded a higher level of management. This will be the open nucleus herd of pure native carabaos.

Foundation cows will be selected on the basis of reproductive efficiency such as sign of first oestrus, services per conception, age at first calving and calving interval. Bulls will be selected based on body size, conformation, testes size and breed characteristics.

# Guidelines for the selection of carabaos for the nucleus herd based on individual phenotype

Selection will be based on age, body weight and measurements, body conformation, health and distinct characteristics .

- 1. Breeding age, preferably between 4–7 years for both male and female. Age determined by certificate of ownership papers and dentition.
- 2. Recommended body weight and measurements for both bulls and cows.

|                  | Age (years) |         |         |         |
|------------------|-------------|---------|---------|---------|
|                  | 1           | 2–3     | 4       | 5–7*    |
| Height (cm)      | 99–104      | 113–118 | 125–131 | 137–142 |
| Heart girth (cm) | 125–132     | 153–163 | 192–197 | 170–181 |
| Body length (cm) | 106–112     | 115–123 | 147–165 | 170–181 |
| Body weight (kg) | 133–158     | 200–280 | 440–460 | 490–590 |
| Priority         | 4th         | 3rd     | 2nd     | 1st     |

\*Additional information for:  
Bulls—number of calves produced.  
Cows—age at first calving or number of calves weaned.

- 3. Body conformation (general form or shape of the animal):  
  
General appearance: size, form (blocky and well proportioned) well muscled and masculine for the male; feminine and well placed teats for the female.  
  
Fore quarters: shoulder moderately sloping, long, wide cleaned forearm, large feet with dense and waxy hooves.  
  
Hind quarters: hips are broad, smooth and level, rump is long, wide and muscular with deep and broad thighs.  
  
Body: chest is full, deep and broad, long and well sprung ribs, back is broad and straight.  
  
Neck: muscular and broad.  
  
For the bulls: testes must be intact.
- 4. Health: glossy hair, wet muzzle and bright eyes.
- 5. Distinct characteristics used to differentiate the native carabao from a crossbred or exotic breed:
  - colour light grey to slate grey
  - horn curved outward and inward forming semi-circle
  - marking: presence of two white narrow stripe across ventral sides of neck, white spots on intermandibular region of lower jaws, whitish stockings ( from knee or hocks downward to pastern)
  - no white patches on top of head or switch.

## **Annex 2**

# **Body scoring criteria for the Philippine carabao**

### **Score**

- 1: Animal is in very poor condition, very thin with prominent scapula, hip and pin bones, and ribs.
- 2: Animal in poor condition but relatively better than that in score I .
- 3: Animal in good condition with hip and pin bones, and ribs discernible but not prominent
- 4: Animal in much better condition with well-covered hip and pin bones and clean cut barrel indicating well-fleshed ribs.
- 5: Animal in excellent condition but not fat.
- 6: Animal in over-fat condition with all bony prominence well-covered with fat.

Conversion table of measurements for carabaos\*  
based on heart girth

| Age**     | Metres | Feet | Inches | Centimetres | Weight (kg) |
|-----------|--------|------|--------|-------------|-------------|
| 12 months | 1.30   | 4.26 | 51.17  | 129.97      | 144.84      |
|           | 1.31   | 4.30 | 51.56  | 130.97      | 149.54      |
|           | 1.32   | 4.33 | 51.96  | 131.97      | 154.24      |
|           | 1.33   | 4.36 | 52.35  | 132.97      | 158.94      |
|           | 1.34   | 4.40 | 52.74  | 133.97      | 163.64      |
|           | 1.35   | 4.43 | 53.14  | 134.98      | 168.39      |
|           | 1.36   | 4.46 | 53.53  | 135.97      | 173.04      |
|           | 1.37   | 4.49 | 53.92  | 136.96      | 177.74      |
|           | 1.38   | 4.53 | 54.32  | 137.97      | 182.43      |
|           | 1.39   | 4.56 | 54.71  | 138.96      | 187.13      |
| 18 months | 1.40   | 4.59 | 55.10  | 139.96      | 191.83      |
|           | 1.41   | 4.62 | 55.50  | 140.96      | 196.53      |
|           | 1.42   | 4.66 | 55.89  | 141.96      | 201.23      |
|           | 1.43   | 4.69 | 56.28  | 142.96      | 205.93      |
|           | 1.44   | 4.72 | 56.68  | 143.97      | 210.65      |
|           | 1.45   | 4.76 | 57.07  | 144.96      | 215.31      |
|           | 1.46   | 4.79 | 57.47  | 145.96      | 220.02      |
|           | 1.47   | 4.82 | 57.86  | 146.96      | 224.72      |
|           | 1.48   | 4.85 | 58.20  | 147.83      | 229.27      |
|           | 1.49   | 4.89 | 58.65  | 148.96      | 234.12      |
| 24 months | 1.50   | 4.92 | 59.04  | 149.96      | 238.82      |
|           | 1.51   | 4.95 | 59.40  | 150.88      | 243.12      |
|           | 1.52   | 4.99 | 59.83  | 151.96      | 248.22      |
|           | 1.53   | 5.02 | 60.22  | 152.96      | 252.92      |
|           | 1.54   | 5.05 | 60.61  | 153.96      | 257.61      |
|           | 1.55   | 5.08 | 61.01  | 154.96      | 262.31      |
|           | 1.56   | 5.12 | 61.40  | 155.96      | 267.01      |
|           | 1.57   | 5.15 | 61.80  | 156.96      | 271.71      |
|           | 1.58   | 5.18 | 62.19  | 157.96      | 276.41      |
|           | 1.59   | 5.22 | 62.58  | 158.95      | 281.08      |
| 36 months | 1.60   | 5.25 | 62.98  | 159.96      | 285.81      |
|           | 1.61   | 5.28 | 63.37  | 160.96      | 290.51      |
|           | 1.62   | 5.31 | 63.76  | 161.96      | 295.21      |
|           | 1.63   | 5.35 | 64.16  | 162.96      | 299.90      |
|           | 1.64   | 5.38 | 64.55  | 163.96      | 304.60      |
|           | 1.65   | 5.41 | 64.94  | 164.96      | 309.30      |
|           | 1.66   | 5.44 | 65.34  | 165.96      | 314.00      |
|           | 1.67   | 5.48 | 65.73  | 166.95      | 318.68      |
|           | 1.68   | 5.51 | 66.12  | 167.94      | 323.34      |
|           | 1.69   | 5.54 | 66.52  | 168.96      | 328.12      |
|           | 1.70   | 5.58 | 66.91  | 169.95      | 332.77      |
|           | 1.71   | 5.61 | 67.31  | 170.96      | 337.49      |
|           | 1.72   | 5.64 | 67.70  | 171.96      | 342.19      |

| Age**     | Metres | Feet | Inches | Centimetres | Weight (kg) |
|-----------|--------|------|--------|-------------|-------------|
| 48 months | 1.73   | 5.67 | 68.04  | 172.82      | 346.26      |
|           | 1.74   | 5.71 | 68.49  | 173.96      | 351.59      |
|           | 1.75   | 5.74 | 68.88  | 174.94      | 356.29      |
|           | 1.76   | 5.77 | 69.27  | 175.95      | 360.99      |
|           | 1.77   | 5.81 | 69.68  | 176.95      | 365.69      |
|           | 1.78   | 5.84 | 70.06  | 177.95      | 370.39      |
|           | 1.79   | 5.87 | 70.45  | 178.95      | 375.08      |
|           | 1.80   | 5.90 | 70.85  | 179.96      | 379.81      |
|           | 1.81   | 5.94 | 71.24  | 180.95      | 384.48      |
|           | 1.82   | 5.97 | 71.64  | 181.95      | 389.18      |
|           | 1.83   | 6.00 | 72.03  | 182.95      | 393.88      |
|           | 1.84   | 6.04 | 72.42  | 183.95      | 398.58      |
|           | 1.85   | 6.07 | 72.82  | 184.95      | 403.28      |
|           | 1.86   | 6.10 | 73.21  | 185.95      | 407.98      |
|           | 1.87   | 6.13 | 73.60  | 186.95      | 412.68      |
|           | 1.88   | 6.17 | 74.00  | 187.95      | 417.37      |
|           | 1.89   | 6.20 | 74.39  | 188.95      | 422.07      |
|           | 1.90   | 6.23 | 74.78  | 189.95      | 426.77      |
|           | 1.91   | 6.26 | 75.18  | 190.95      | 431.15      |
|           | 1.92   | 6.30 | 75.57  | 191.95      | 436.17      |
| 60 months | 1.93   | 6.33 | 75.96  | 192.95      | 440.87      |
|           | 1.94   | 6.36 | 76.36  | 193.95      | 445.57      |
|           | 1.95   | 6.40 | 76.75  | 194.95      | 450.24      |
|           | 1.96   | 6.43 | 77.15  | 195.95      | 454.96      |
|           | 1.97   | 6.46 | 77.54  | 196.95      | 459.67      |
|           | 1.98   | 6.49 | 77.93  | 197.95      | 464.36      |
|           | 1.99   | 6.53 | 78.36  | 199.03      | 469.46      |
|           | 2.00   | 6.56 | 78.72  | 199.95      | 473.76      |
|           | 2.01   | 6.59 | 79.11  | 200.94      | 478.70      |
|           | 2.02   | 6.63 | 79.51  | 201.96      | 483.40      |
|           | 2.03   | 6.66 | 79.90  | 202.95      | 488.10      |
|           | 2.04   | 6.69 | 80.28  | 203.91      | 492.80      |
|           | 2.05   | 6.72 | 80.69  | 204.95      | 497.50      |
|           | 2.06   | 6.76 | 81.12  | 206.04      | 502.80      |
|           | 2.07   | 6.79 | 81.46  | 206.91      | 506.90      |
|           | 2.08   | 6.82 | 81.87  | 207.95      | 517 .60     |
|           | 2.09   | 6.86 | 82.26  | 208.94      | 516.30      |
|           | 2.10   | 6.89 | 82.66  | 209.96      | 521.00      |
|           | 2.11   | 6.92 | 83.05  | 210.95      | 525.70      |
|           | 2.12   | 6.95 | 83.44  | 211.94      | 530.40      |
|           | 2.13   | 6.99 | 83.88  | 213.06      | 535.10      |
|           | 2.14   | 7.02 | 84.23  | 213.95      | 539.80      |
|           | 2.15   | 7.05 | 84.62  | 214.95      | 544.50      |
|           | 2.16   | 7.08 | 85.02  | 215.94      | 549.20      |
|           | 2.17   | 7.12 | 85.41  | 216.94      | 553.90      |
|           | 2.18   | 7.15 | 85.80  | 217.94      | 558.60      |
|           | 2.19   | 7.18 | 86.20  | 218.94      | 563.60      |
|           | 2.20   | 7.22 | 86.59  | 219.94      | 568.00      |

| Age** | Metres | Feet | Inches | Centimetres | Weight (kg) |
|-------|--------|------|--------|-------------|-------------|
|       | 2.21   | 7.25 | 86.99  | 220.94      | 572.70      |
|       | 2.22   | 7.28 | 87.48  | 222.20      | 577.40      |
|       | 2.23   | 7:31 | 87.77  | 222.94      | 582.10      |
|       | 2.24   | 7.35 | 88.17  | 223.94      | 586.80      |
|       | 2.25   | 7.38 | 88.85  | 224.94      | 591.50      |
|       | 2.26   | 7.41 | 88.95  | 225.94      | 596.20      |
|       | 2.27   | 7.45 | 89.35  | 226.94      | 600.90      |
|       | 2.28   | 7.49 | 89.74  | 227.94      | 605.60      |
|       | 2.29   | 7.51 | 90.13  | 228.94      | 610.30      |
|       | 2.30   | 7.54 | 90.48  | 229.82      | 615.00      |

\* Based on the equation: Estimated weight (kg) =  $4.7x - 466$ , where  $x$  = heart girth (cm).

\*\*Approximate age based on PHI/86/005. Field Document No. 13 Book Series No. 126/1992.

# **Guide in estimating age of Philippine buffaloes by dentition**

The central and medial temporary incisors appear at birth and others are visible below. All four pairs are fully developed and complete by the age of three and a half months. The incisors are relatively small, white and with distinct neck, unlike the permanent teeth that are much stronger and with a darker (stained) colour.

- The first pair (central) of permanent incisors erupt from the age of 2 years 6 months to 3 years 3 months among carabaos ( average of 2 years 10 months)
- The second pair or permanent incisors appears between 3 and 4 years (average of 3 years and 4 months). The third pair of permanent incisors erupts between 3 years 6 months of age and 5 years 1 month (4 years 2 months average). The fourth pair of permanent incisor erupts between 4 years 1 month and 5 years 6 months (average of 4 years 8 months)
- Permanent incisors are level at 9–10 years of age and reduction begins at 11–12 years of age. Beyond 12 years it would be difficult to estimate the age of the buffalo based on dentition.

The guidelines commonly used by farmers and buyers are:

1. Complete first permanent incisors = 2 to 3 years of age.
2. Complete second permanent incisors = 3 to 4 years of age.
3. Complete third permanent incisors = 4 to 5 years of age.
4. Complete fourth permanent incisors 5 or more years of age. This must be viewed in relation to the horn size and general body condition.

Depending on the amount of eruption in relation to the other teeth, estimates can be given, e.g. if the second permanent incisors are just appearing or halfway erupted, the animal is 3 years 6 months old.

**Individual data sheet**

Date of visit:.....

Location: Brgy:.....Town/City:.....Province:.....Region:.....

Owner/raiser: .....

Identification of the animal:..... Procured from: .....

Age (years/months): ..... Sex:..... Breed: .....

Body weight (kg):..... Heart girth (cm): .....

Physical genetic defects (if any): ..... Condition: .....

Degree of relationship with other carabaos within the herd:

.....  
.....  
.....

For bulls/cows between 4–7 yrs:

No. of calves produced: .....

Age at first calving: .....

Number of calves weaned: .....

Other remarks: .....

Evaluator: .....

Date of evaluation: .....

# The carabao genetic improvement programme<sup>1</sup>

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1. A breeding programme proposed at the National Research and Development Review, Consultation and Workshop on Water Buffalo sponsored by the Philippine Carabao Centre (PCC), 20–22 April 1994, Continuing Education Centre, University of the Philippines at Los Banos (UPLB), Laguna.
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## Executive summary

A long-term national breeding programme is proposed to genetically improve (primarily, but not exclusively limited to) milk production of local water buffaloes in many smallholder and institutional farms in the Philippines. The relative importance of meat and draft power will be appropriately considered in the pre-defined breeding objectives and selection criteria.

In line with the Medium Term Livestock Development Plan (1993–1998) of the Department of Agriculture (DA),  $F_1$  crosses between the imported riverine (Murrah) buffaloes and the Philippine native carabaos will be produced. In the long-term, the same buffalo hybrids will be stabilised in order to sustain genetic improvement through a rigid animal performance testing and selection programme. At the same time, efforts will be made to properly conserve and improve the genetic value and identity of the native Carabao. The aim is to stratify the breeding population into one which is dominated by the high performing stabilised  $F_1$  crosses. The breeding structure should also include an adequately-sized gene pool of highly selected native carabaos and should be able to restrict the importance of superior Murrah genes.

A local testing and selection programme will be organised through the creation of a standardised milk recording system necessary for efficient individual, progeny, sib or pedigree testing in dispersed or centralised nucleus breeding units. A regular performance evaluation of the imported Murrah,  $F_1$  and subsequent crosses, and native carabaos will be used to identify and select superior breeding animals nation-wide .

The success of the breeding programme will depend on a combination of a well-defined breeding objective and selection criteria, availability of superior animals, improved size, distribution, and management systems in smallholder herds, higher success rates in the use of reproductive biotechnology, lower costs of running a testing and selection programme, animal transfers and dissemination schemes, and strong political will .

## Introduction

A recent assessment (e.g. Faylon and Ranjhan 1992) of the existing mating plans, population numbers of various breed groups, multiplication programmes, success rates of reproductive technologies (i.e. natural mating, oestrus synchronisation,

artificial insemination (AI), multiple ovulation and embryo transfer (MOET) etc) in water buffaloes under Philippine field situations, all point towards the synthesis of a national breeding programme for the genetic improvement of carabaos.

Past experiences of the Philippine Carabao Research and Development Centre (PCRDC), are summarised by Hodges (1991). These experiences showed that from 1981 to 1991, a large-scale crossbreeding project was executed by FAO/UNDP and implemented by the Government of the Philippines at six locations. The project aimed to cross the swamp buffalo (Carabao) which has 48 chromosomes, with the riverine buffalo of India and Pakistan which has 50 chromosomes. The latter is a larger animal, and has, in several of its breeds including the Murrah and the NiliRavi, a much higher milk production than the swamp buffalo. The riverine type has been used on the swamp buffalo females. The  $F_1$  cross is a larger animal, which works better and produces more meat and milk. These qualities are reflected in the higher market value of the crossbreds and in the enthusiasm of the owners whose families own usually one or two animals each.  $F_2$  animals have been produced and the reproductive performances of the  $F_1$  and  $F_2$  is due for appraisal. Preliminary results indicate no major problems, which is perhaps surprising in view of the expected infertility of male or female animals or both in many inter-species crosses between closely related species. If the buffalo crossbreds in succeeding generations are in fact normal in reproduction, then this crossbreeding programme appears to contribute in one step, a considerable improvement in production.

From a crossbreeding project, the Philippine Carabao Centre (PCC) has now evolved to lead the implementation of a long-term national breeding programme from Carabao. The programme will initially involve 13 regional centre and 67 regional breeding stations, and 153 AI centres nation-wide. The two national centres of the network are the PCC at the University of the Philippines at Los Banos (UPLB) and the PCC at Central Luzon State University (CLSU).

## **Proposed carabao breeding framework**

### **Breeding objective and selection criteria**

#### **Definition of the breeding objective**

The breeding programme primarily aims to genetically improve the quantity of milk produced in a structured population composed of imported Murrah bulls (or semen for AI), Philippine native carabaos, and Murrah x Carabao crosses.

The production of milk is assumed to be closely correlated with total economic merit. With the establishment of milk-testing equipment or laboratories in the future, economic traits related to the quality of milk such as fat and protein percentages may be included in the breeding objective. Similarly, correlated changes in reproductive performance, meat and draft potentials will also be monitored through the appropriate and timely measurements in the smallholder and nucleus farms.

In the absence of factual data in smallholder herds, parameter estimates for specialised milk production systems (i.e. institutional and private herds) in the tropics can be used to predict theoretical response to selection. These parameter estimates are probably too high, but can set the upper limits in smallholder breeding systems.

In the long run, the smallholder farmers must always be involved or consulted in the genetic decision making to keep the breeding schemes (with a simple definition

of the breeding goal) relevant to practice. A co-operative type of breeding and decision-making system is also suggested with the aim to integrate farmers resources, reduce overhead costs, and hopefully encourage more farmer participation. Elaboration of the breeding objective and the use of new technologies or more complex breeding systems to increase the rate of genetic change can be developed later.

### **The nucleus breeding strategy**

A structured breeding population of water buffaloes, divided into the institutional (PCC-based nucleus) and smallholder (base) herds, will be established. Selection will be for the same trait(s) on both tiers, based on a standardised milk recording system. Initial breeding work (including recording, genetic evaluation, selection, and the conduct of experiments on new, expensive biotechnologies on artificial breeding such as organised AI services, oestrus control, and the MOET) will be concentrated in the nucleus (dispersed or centralised). Animals may, therefore, be assessed with better control over management to ensure a fair test of merit.

Although the smallholder based herds may initially be unrecorded, milk recording in the nucleus herds will be encouraged to cover as wide a population as possible. The goal will be to emphasise the importance of keeping animal performance records that will be useful in promoting "grassroots" awareness on better management, accurate estimation of genetic merit, identification of superior breeding germs, and increase yields and economic returns in many smallholder farms.

Dissemination of genetic improvement from the nucleus to the smallholder herds will primarily be through the use of nucleus-tested males on selected females born in the villages or smallholder farms, through natural mating (e.g. bull dispersal programmes) or artificial insemination (AI). In many situations, however, the use of natural mating continues to be the only workable system to disseminate the germplasm from the nucleus herds to the remainder of the commercial population. Thus, it may be necessary to produce more commercial bulls (i.e. "island-born") in the nucleus for natural mating of the base population. In the future, superior males and females from the smallholder herds may be transferred for use into the nucleus herds to increase selection intensity.

### **Screening of foundation and replacement stocks**

The screening methods for foundation stocks and replacement in the two-tier open nucleus breeding system are described below.

*Foundation stocks.* The selection programme for foundation stocks involves the initial screening of high producing animals to form the nucleus or elite herd(s). In the case of the unrecorded base population, apparently superior females will be screened initially through a very similar recording system introduced temporarily in the field or by relying upon the smallholder farmers knowledge of the animals. For example, a simple selection procedure will be on assessed milking ability and fertility, with some attention to size, conformation and condition. Where possible, test milking will be carried out. Adjusting for simple effects, such as those of management and age of cows, will be important.

Because of the large number of smallholder herds available and apparently large between-herd and within-herd genetic variation, highly selected individuals should come from many herds. Use will be made of already existing elite herds (e.g. PCC

network centres and private dairy farms such as Select a), perhaps relying on progeny testing and/or a selection programme for many years. This automatically selects foundation stocks from one genetically improved herd. Organisation problems may also be avoided with already established nucleus herds. An alternative would be to consider the newly imported batch of Murrah bulls and cows as another nucleus unit distributed to at least two locations. This would serve as an ample source of the Murrah genotype required in the formation of Murrah-carabao crosses. "Swapping" or exchange of bulls (or cows, in some cases) among the nucleus farms will be encouraged but should be based primarily on superior genetic merit.

In any case, the objectives of improvements will be defined clearly and these objectives have to be accepted or agreed upon (on a continuous basis and with a long-term commitment) by the participating smallholder dairy farmers and the PCC management.

*Replacement stocks.* The continuation selection programme for replacement stocks will be implemented as soon as the nucleus is established, while keeping the nucleus open. Unlike the initial screening policy, emphasis will be mainly on the proportion of the nucleus replacements born in the smallholder herds (assuming that there are enough breeding animals available for selection) and the extent to which animals born in the base are tested. With better reproduction technology to improve reproductive rates in the nucleus, it is expected that a lower proportion of base-born females will be required to be selected.

To check on the value of screening superior individuals from the smallholder herds, it is suggested that an average (control) individual should be taken, and a control line established. This will also demonstrate to farmers the use of screening, and encourage them to contribute their best individuals (or be shown to be poor judges of genetic merit). A small control, bred from frozen semen from a number of control males in the first generation, may be used to mark genetic change in the breeding programme.

## **Selection targets**

Depending on the available number of animals that are candidates for selection for each mating type in the nucleus:

- a) The best bulls ( 1/20) will be selected (based on progeny test for milk production and performance test for growth rate) to breed bulls for progeny testing, of which the best bulls (1/5) will be gathered in an AI stud for general use.
- b) Young unproven bulls will be selected based on the pedigree (i.e. sire's or grand sires estimated transmitting ability) and mated randomly to cows up to a maximum 20% of all matings. Yearly bulls may be selected based on growth rate.
- c) The top 1/50 or 2% dams will be selected as dams of bulls in the dispersed or centralised nucleus based on three records. Other cows will be indexed for milk yield on the basis of their own records, dams records, and sires proof. High indexing cows for production may be further screened on the basis of fat and protein percentage, type, temperament, and fertility.

Population structure and breeding systems

The composition of the breeding structure will be monitored systematically and controlled by giving priority to the production of the major mating types (i.e. Murrah sires x carabao females, *inter se* mating of Murrah–carabao crosses, and the pure breeding of Philippine native carabaos) in both the nucleus and the smallholder herds. For example, see Table 1.

**Table 1.** Priority of producing the major mating types in institutional (nucleus) and smallholder-based herds.

| Time frame     | Nucleus herds     | Priority | Smallholder base herds | Priority |
|----------------|-------------------|----------|------------------------|----------|
| Initial (base) | Murrah x Carabao  | ??       | Murrah x Carabao       | ??       |
|                | Cross x Cross     | ??       | Cross x Cross          | ??       |
|                | Carabao x Carabao | ??       | Carabao x Carabao      | ??       |
| Medium term    | Murrah x Carabao  | 1        | Murrah x Carabao       | 1        |
|                | Cross x Cross     | 2        | Cross x Cross          | 2        |
|                | Carabao x Carabao | 3        | Carabao x Carabao      | 3        |
| Long term      | Murrah x Carabao  | 3        | Murrah x Carabao       | 3        |
|                | Cross x Cross     | 2        | Cross x Cross          | 2        |
|                | Carabao x Carabao | 1        | Carabao x Carabao      | 1        |

?? = Unknown proportion of mating types.

Murrah = Imported Murrah sires.

Carabao = Philippine native carabaos.

Crosses = Murrah x Carabao crosses.

1. Short and/or medium term

The main thrust of the mating system should be towards the upgrading of the carabao (producing about 1–2 kg milk per day) using imported (and supposedly selected) Murrah bulls or semen. AI services may be contracted to local or foreign groups to service a bigger proportion of the total carabao population. It should be emphasised that crossbreeding is not to be used as a substitute for good management, nor is it to be used as a "cure-all" technology for unproductive carabaos. Hence, a good crossbreeding programme will probably require a higher level of management in order to maximise the potential of the animal. Through continuous training seminars or workshops, farmer/breeders will be warned as to the requirements for possible changes in the herd nutritional programme as more productive buffaloes will be produced.

The goal of cross breeding (or species hybridisation) is primarily to take advantage of the genetic improvement in fertility, maternal performance, and milk production through hybrid vigour or heterosis. At the same time, selection will be used to accumulate the additive gene actions known to affect the selection criteria. Hence, the best animals within the Murrah sires and within the Carabao females will have to be carefully selected (if F<sub>1</sub> female crosses are already available for breeding, selected F<sub>1</sub> crossbred males will then be used on them). While the Murrah and the Carabao have markedly different performance levels in terms of milk yield, the level of performance of the crosses which exhibits heterosis, may not exceed that of the Murrah. It is also expected that buffaloes belonging of the F<sub>2</sub> generation (i.e.

*inter se* of the  $F_1$ s) will perform below that of  $F_1$ s, since it is difficult, if not impossible, to fix heterosis due to dominance and epistasis (interaction) .

Terminal cross breeding is not recommended since a large population size of selected Carabao females and a continuous importation of Murrah semen will be required. Also, breed replacement is currently a remote option, even if the transfer of germplasm and genetic stocks across countries is at present largely unrestricted. Benefits may arise automatically from genetic improvement programmes abroad, but this may be expensive, incompatible with the local goals, production and marketing systems, and may contribute to future problems of reduced genetic diversity and consequently, the loss of the native Philippine Carabao.

At this time, a second priority may be given to *inter se* mating of the  $F_1$  crosses, while allowing the breeding of selected carabulls with selected caracows. Selection among the carabaos will also ensure the conservation of their unique adaptive attributes. This scheme will be in line with the "Save the Herd" programme that will be implemented for the genetic conservation of the carabao. The forms of conserving the genetic quality of the carabao (and crosses that allow them to be stabilised in the future) will be a combination of live animals and cryopreserved germplasm (i.e. semen, eggs, and/or embryos). The population sizes of these selected and "preserved" gene pools will be established early in the breeding programme in order to avoid the detrimental effects of inbreeding and sampling (genetic drift). The frozen genotypes will have to be tested regularly (e.g. every five to seven years) in order to assess and underscore their importance in the industry.

## 2. Long term

The Murrah–carabao crosses will be stabilised through several generations of selection. In the long term also, an adequately-sized gene pool of native carabaos will be organised to co-ordinate and facilitate the exchange/transfer of data diskettes for proper evaluation and early return of results to the farmer/breeder co-operators. The PCC-MDPO will also be required to keep and update information on:

- General farm/herd level information
- Pasture management and nutrition
- Herd health problems
- Culling and selection
- Management of breeding animals
- Calf and heifer management
- Milk production and reproductive performance

## Changes in recording

Technical changes in milk recording and sire and cow evaluation systems have to be made through the approval of the Management Committee and Technical Review Committee of the PCC.

If there would be difficulty in measuring the economic traits under actual field conditions, other highly correlated traits (such as early or partial lactation, records, chromosome number or presence of a major gene) which are heritable and can be measured at lower costs may be identified and monitored instead.

*Statistical evaluations.* Institutional (nucleus or elite) and field (smallholder base herds) records will be analysed to estimate and compare individual breeding values, and variance components. Genetic and phenotypic trends will also be estimated for various traits of economic importance in water buffaloes raised under smallholder production systems. This will include milk production, reproductive performance, birth, weaning, and yearling weights, mature body weights, draft ability etc to be conserved. The genetic improvement in milk production in both breed groups of water buffaloes will be sustained (although at a slow rate, but will be permanent and cumulative) through a deliberate and continuous local testing and selection programme. Thus, the requirement for imported Murrah semen will eventually end. Dissemination of genetic improvement to the population at large will be done through organised schemes involving regional breeding stations and AI centres that will distribute live animals, frozen semen, and embryos.

## **Recording and evaluation system**

The genetic improvement programme for carabaos in the Philippines is usually constrained by the expensive requirements for a population-wide, recording infrastructure. This problem is characterised by the difficulty in organising good information collection and collation programmes, even if better computer power and statistical methodology are now available. The small animal population sizes and their scattered distribution over a variable range of production and marketing environments are also known to complicate the problem. Despite the above-mentioned constraints, workable wording and evaluation systems are proposed.

### **1. Milk recording programme**

#### **(a) Scope**

Milk recording will be encouraged in all smallholder and nucleus farms. In order to dispense with the expensive requirements of a population-wide infrastructure, recording and selection will be initially carried out in the nucleus. The nucleus herds (e.g. minimum of 50 to 100 breeding females per farm) will initially be identified and shall include the PCC network centre (including the Bull Stud at Isabela State University and other fully established dairy herds or co-operatives). Regular seminar-workshops involving all identified units will be conducted to ensure strict adherence to the recording system. All females in the smallholder herds will eventually be performance tested for milk production.

The PCC will provide the testing laboratories (for milk fat and protein contents) and computer facilities for summarising milk record and for sire and cow evaluations.

#### **(b) Type of records**

A standardised, computerised monitoring system will be developed by the PCC to record the volume (kg) of milk produced per lactation by all female animals, which shall constitute the selection criterion. All individual cow performance, progeny and/or sib data (especially for male candidates for selection) will be collected on a continuous basis.

Important data to be gathered will include animal ID, sire and dam ID, blood composition or breed group, date of calving, total milk yield, and body weights at birth, weaning, and one year of age. Other reproductive measures such as services per conception, calving interval, and days open may also be considered .

Data on the (1) management level (which can usually be associated with herd, time of year, and year), (2) age of the animal, (3) lactation number, and (4) lactation length, will be collected and used to compare the records fairly.

An example of the relative emphasis on traits and how they will be measured is enumerated in Table 2. These records are relevant and consistent with short/medium-term and long-term selection goals, policies, and guidelines developed to institutionalise the mating system. This will be national in scope and collected through PCC farms, identified nucleus herds and established co-operative testing programmes distributed over the country.

(c) Database and management

All animal records will be entered into a data bank. The recording infrastructure will make use of simple, standard spread sheet software such as LOTUS 123 or QUATTRO to allow easy and efficient storage, formatting, collection, inputting, and updating of data, and transformation of these into ASCII files which is necessary in the evaluation of large data sets using the microcomputer or a mainframe computer. A networking system will be handled by the PCC Milk Data Processing Office (MDPO).

**Table 2.** *Relative emphasis on traits and how they will be measured.*

| Traits to be measured                | Relative emphasis | How they are measured                |
|--------------------------------------|-------------------|--------------------------------------|
| Milk yield                           | High              | Monthly monitoring 'elite herds'     |
| Protein and fat percentage           | Medium            | Sampling in testing laboratories     |
| Growth rate of sires                 | High              | Measured from 1 to 12 months of age  |
| Upper conformation, type traits      | Medium            | Dairy persons within each herd       |
| Temperament, calving ease, fertility | Low               | Dairy persons and AI/breeding centre |

2. Data analyses

(a) New technologies

Contributions of new reproductive biotechnologies (AI, MOET, *in vitro* fertilisation or IVF, cloning) in the genetic improvement of carabaos and crosses under smallholder production systems will also be predicted and compared with realised genetic gains.

(b) "BLUP" animal models

The Best Linear Unbiased Prediction (BLUP) mixed model methodology or animal models will be used to estimate genetic and phenotypic parameters of single traits and/or multiple traits simultaneously. All recorded parents (and grandparents) will be included in the relationship matrix. Across and within breed genetic evaluations will be computed and published at least once a year. The published sire proofs and cow indices will correspond to the breeding values (and accuracies) of males and females, respectively. In the future, official production certificates may be issued to producers to allow them to better promote and market their animals.

The BLUP solutions should be able to provide estimates of

- the effects of various genetic and non-genetic factors influencing milk production

- change in milk productivity over time
- genetic and phenotypic variance, response to selection, and breeding values of each animal.

These results will be used for selecting superior animals and also to optimise the use of the Carabao, Murrah and their crosses in the genetic improvement of milk yield among local water buffaloes. Specifically, the estimated breeding values (EBVs) for a single trait per se (e.g. first lactation record) or EBVs in combination with EBVs of other important traits must be the basis for selection. Estimated parameters for reproductive performance of cows would also help to compare various breed groups for overall productivity.

### (c) Computing

Evaluation of the above records will be done by editing, summarising, and submitting them to the genetic evaluation centre proposed at the Animal Breeding Division, Institute of Animal Science, UPLB. Computing will involve the use of high-memory microcomputers and the university mainframe computer. Results of the genetic evaluations of the animals will be published and distributed after the animals complete the tests. Faster, more accurate, and cost-effective computer programmes will be continuously developed to analyse the local data sets using proper statistical methods.

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# **ILRI Consultation on Livestock Research Priorities in South-East Asia 10–13 May 1995, IRRI, Los Banos, Philippines**

## **Day 1: Wednesday, 10th**

Registration

### **Session I: Welcome and Opening Ceremony**

Welcome and opening address by F.A. Bernardo, Deputy Director General for International Services, IRRI

**Chairman – F.A. Bernardo**

Introduction to the objectives of the meeting by H. Fitzhugh, Director General, ILRI

Keynote address by R. Nazareno, Assistant Secretary, Department of Agriculture, the Philippines

### **Session II: Elements of livestock production systems improvement**

**Chairman – A.W. Qureshi**

Paper 1: *Research and development for fodder production and supply in South East Asia* by W. Stur

Paper 2: *Priorities and direction for research in more effective use of feed resources by livestock in Asia* by R. Leng and C. Devendra

Discussion

Paper 3: *FAO and APHCA initiatives and contributions to the development of livestock agriculture in South-East Asia* by M. Sasaki

Paper 4: *Effective conservation and utilisation of indigenous animal genetic resources. The development of the Carabao in the Philippines* by L. Cruz

Paper 5: *Research priorities for mixed fish/crop/livestock farming improvement in South-East Asia* by P. Edwards and David Little

Discussion

## **Day 2: Thursday, 11th**

### **Session III: International approaches to the agricultural and livestock research in the humid/subhumid ecozone of Asia**

**Chairman – P. Carroll**

Paper 6: *The criteria for determining the agricultural research priorities in the humid/subhumid zones of South-East Asia* by K.S. Fischer

Paper 7: *Priorities for socio-economic research in farming systems in South-East Asia* by T.R. Paris and C. Sevilla

Paper 8: *ICLARM's approach to the integration of aquaculture into sustainable farming systems* by M. Prem, C. Lightfoot and R.S.V. Pullin

Additional paper (i) *The development of the CGIAR's System-wide Livestock Initiative* by D. Thomas

Additional paper (ii) *Brief review of the approach to livestock development of the Asian Development Bank* by P. Carroll

General Discussion

## **Session IV: National and regional approaches to mixed livestock/crop production systems improvement**

**Chairman – Vo-Tong Xuan**

Paper 9: *Research priorities for improving animal agriculture by agro-ecological zone in Malaysia* by T.K. Mukherjee

Paper 10: *Research priorities for improving animal agriculture by agro-ecological zone in the Philippines* by P. Faylon and D. Roxas

Paper 11: *Research priorities for improving animal agriculture by agro-ecological zone in Indonesia* by A. Djajanegara and K. Diwyanto

General Discussion

## **Day 3: Friday, 12th**

### **Session IV continued**

**Chairman – L. Cruz**

Paper 12: *Research priorities for improving animal agriculture by agro-ecological zone in Thailand* by M. Wanapat

Paper 13: *Research priorities for improving animal agriculture by agro-ecological zone in Vietnam* by Vo-Tong Xuan, Le Thanh Hai and Chau Ba Loc

Paper 14: *Research priorities for improving animal agriculture by agro-ecological zone in Laos* by B. Bounthong

General Discussion

### **Session IV continued**

**Chairman – A. Hall**

Additional paper (iii) *Some observation on livestock programmes in South China* by Liu Guodao (no transcript made of impromptu presentation)

Paper 15: *Research priorities for improving animal agriculture in Papua New Guinea* by B. Bakau

Paper 16: *Research priorities for improving animal agriculture in Fiji* by P. Manuelli (scheduled paper not given but text appears in current proceedings)

General Discussion and introduction to Working Groups

## **Day 4: Saturday, 13th**

### **Session V: Working Group Discussions**

Working Group Discussions in two groups:

I. Indo-China

Chairman: Vo-Tong Xuan, Rapporteur: Douglas Little

II. ASEAN

Chairman: T. Komiyama, Rapporteur: C. Devendra

#### **Chairman – P. Gardiner**

Presentation and discussion of group reports on major livestock research priorities by subregion

Close of meeting by K.S. Fischer, Deputy Director General for Research, IRRI

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