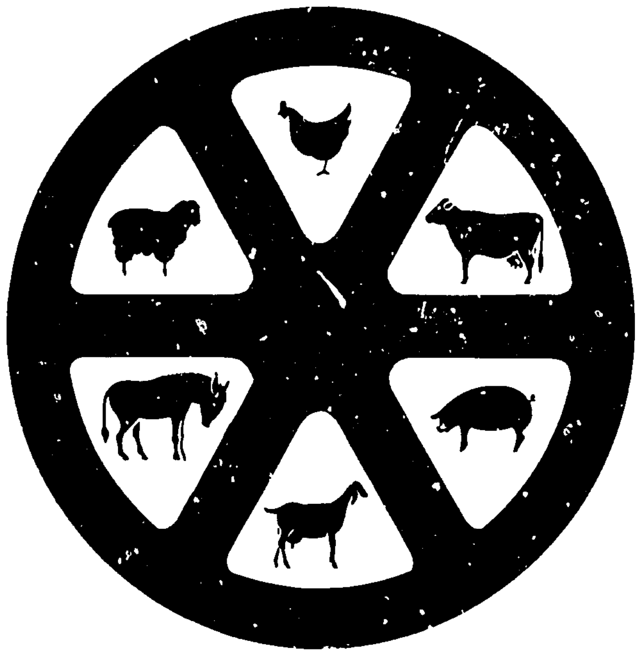
Summary Report of the
Animal Agriculture Symposium: Development Priorities Toward the Year 2000

June 1-3, 1988
Washington Dulles Airport Marriott
Chantilly, Virginia



Agency for International Development
Bureau for Science and Technology
Office of Agriculture
in collaboration with the
U.S. Department of Agriculture
Office of International Development

Summary Report of the

Animal Agriculture Symposium: Development Priorities Toward the Year 2000

June 1-3, 1988
Washington Dulles Airport Marriott
Chantilly, Virginia

Agency for International Development
Washington, D.C. 1989

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

Page

APPENDICES:

EXECUTIVE SUMMARY

The countries of the developing world contain 58% of the world's total land area, with 60% of the world's permanent pasture, and 53% of the world's arable land. These countries have 65% of the world's cattle, 53% of the world's sheep, 56% of the world's pigs, and 95% of the world's goats. The total number of livestock in the world indicates their importance as an economic resource. FAO figures show that in 1986 there were 1.4 billion cattle and buffalo, 1.6 billion sheep and goats, 9.3 billion poultry (including ducks and turkeys), 822 million pigs, 17 million camels, and 120 million horses, mules, and donkeys.

In examining the needs of Third World countries, the International Food Policy Research Institute notes that "As per capita incomes rise in Third World countries, the demand for livestock products -- meat, milk, and eggs -- not only rises faster than that for cereals in these countries but also more rapidly than demand for livestock products in the developed countries. This in turn influences the demand for cereals and other staple foods used as livestock feed. Livestock production is also an important source of income and employment in the rural sector; it helps to meet equity objectives by contributing cash income to small farmers in the Third World." Demand for animal products has grown as incomes rise and is projected to continue to increase in those countries with consistent positive real rates of growth.

In reassessing the needs of animal agriculture in developing countries, the Agency for International Development sponsored a three-day symposium. More than 150 representatives from universities, public and private sector institutions, donor agencies, and PVOs met at the Dulles Marriott Hotel in Chantilly, Virginia, June 1-3, 1988 to participate in the Animal Agriculture Symposium. This symposium, the first of its kind, was sponsored by the Office of Agriculture, Bureau for Science and Technology to examine the contribution of animals to sustainable agriculture and identify developmental opportunities as we approach the year 2000.

USAID Administrator Alan Woods opened the Symposium by reminding the attendees that "Animal agriculture is finally being recognized as every bit as important to sustained development as advances in grain agriculture. As important as the Green Revolution has been, special attention is now being given to livestock production and the supporting activities that go with it since animals have an extremely important role in almost every aspect of a developed and developing country's economy and culture." He cited figures that indicated that in 1986 "the import/export value of cattle, sheep, goats, and pigs exceeded $75 billion worldwide and animal agriculture accounts for more than $7 billion of the U.S. exports. Without livestock, developing countries would have to spend an additional $40 billion on mechanical power and $6 billion on fertilizers."

A key reason for encouraging animal agriculture in development, according to Administrator Woods, is "that improvements in livestock production are the key to raising income levels in developing countries. It is difficult to conceive of sustained increases in incomes -- particularly to the incomes of small farmers -- without paying attention to animal agriculture development activities." He challenged the Symposium participants to work hard to identify animal agriculture developmental opportunities that the Agency can mold into a strategy to help USAID plan its program during the next decade.

Dr. N.C. Brady, Senior Assistant Administrator for Science and Technology, welcomed Symposium participants, noting:

> "This is a time of grave concern in international development and especially international agricultural development. U.S. Government budget constraints have impacted on USAID programs, and on international agricultural assistance in particular, for several reasons. The agriculture, rural development, and nutrition sector receives the Agency's largest budget and is, therefore, subject to reduction to meet mandated cuts. Of even greater significance is the lack of domestic support for agriculture as compared to programs that deal with child survival, family planning, primary education, biological diversity, and other causes that have active domestic support. By contrast, there has been vigorous domestic opposition to some of USAID's overseas work in agriculture. To counter this lack of active domestic support, the Agency is reassessing priorities and reaching out to the U.S. agricultural community for help. This conference initiated by the Agency's Agricultural Sector Council is one such effort which focuses on animal agriculture and its priorities over the next decade."

Dr. Brady went on to note that in the past, several arguments have been used against animal agriculture. One is that calories and protein can be provided more efficiently by direct human consumption of cereals, edible legumes, roots, and tubers. Another is that animal projects are more costly, more difficult to organize and manage, and take longer to produce results. As a result, USAID has had only a few successful animal projects, and these activities have not been considered a high priority.

Brady emphasized:

> "Now however, we believe the time is right to assess the role of animal agriculture in the context of our efforts to promote sustainable agriculture in the developing countries. We know that animals are important in the rural cultures of many developing countries, particularly those with a strong nomadic and herding tradition. We know, too, that in large areas of the developing world, animals present opportunities for food production on land that has little other agricultural use. Unfortunately, overgrazing of some of these areas, as well as cultivation of marginal lands, has led to desertification, soil erosion, and other problems. Finally, we recognize that for many small LDC farmers animal traction is the main source of on-farm power for plant-based agriculture and that animal wastes provide fuel for cooking as well as fertilizer for crops. What we need to know is how important animal agriculture is to sustainable agricultural development in particular LDC situations, and how high a priority USAID should place on assisting animal agriculture in those situations. That is the essential purpose of this conference."

Dr. Brady asked the conference attendees "to assess the present and to look forward to the future." He closed his remarks by posing several questions:

1. What are the situations in which animal research and development activities are most needed to enhance sustainable agriculture in the developing countries?

2. Which priority problem areas are best addressed by the United States and USAID? Which should be left for other donors? And which can be best addressed through international mechanisms?

3. How might USAID's efforts be linked with U.S. domestic programs, with the efforts of other donors, and with the international agricultural research centers?

4. What steps must be taken to conceptualize animal science programs, to communicate the potential of these programs to decision makers in the U.S. and overseas, and to mobilize the human and financial resources to carry out such programs?

Dr. Brady challenged the conferees to identify and articulate realistic and appropriate recommendations for USAID in addressing animal agriculture in the next decade.

In response to the message from Dr. Brady, the Symposium generated information and recommendations relating to more effective production and utilization of animals and animal-related activities. Speakers, moderators, and discussants provided state-of-the-art information and identified issues, opportunities, and priorities for animal agriculture in development. The papers discussed by smaller work groups addressed selected issues in technology, infrastructure, environmental/natural resource management, economics, policy, institutional/ organizational and sociological issues. Based on the results of the working groups, opportunities in development and support functions for recipients and donors were identified and presented to the last plenary session. These recommendations were considered by the long-range Planning Committee to coordinate and set priorities for many ideas that emerged.

The objectives of this symposium were to assist USAID to:

- Synthesize donor experience with animal agriculture and assess the appropriateness of donor policy and strategy for assistance to this subsector.

- Identify and set priorities for opportunities that would significantly ameliorate constraints and/or develop opportunities to improve the sustainability of animal agriculture systems.

Three topical areas were considered: (1) production systems, (2) institutional and human resource development, and (3) donors and development resources. Some principal issues that emerged relating to these topics were:

Production Systems:

- Land use/tenure are primary considerations in the development of animal agriculture systems.

- Priority emphasis should be placed on mixed crop/livestock systems since most crops and livestock are produced in these systems.

- Continued attention must be given to improving the interface between natural resource management and animal agriculture.

Institutional and Human Resource Development:

- Continued emphasis must be placed on training developing country nationals involved in research, extension, and training.
- Linkages must be strengthened between national agricultural researchers and international agricultural research centers, as well as with universities/institutions in developed countries.
- Research/extension linkages need to be expanded.

Donors and Development Resources:

- Balance must be maintained between priorities as delineated by the host country, opportunities for success as envisioned by donors, and flexibility of thrust required by changes within a country.
- Linkages must be expanded within the U.S. development community and among international donors assisting host countries.
- The private sector must become increasingly involved in animal agricultural programs.

A long-range Planning Committee convened immediately after the last plenary session to evaluate and synthesize the issues, opportunities, and priorities originating from the Symposium and to develop preliminary conclusions, recommendations, and steps in formulating a strategy for animal agriculture for USAID. Committee members included representatives of USAID, the public and private sectors, and international organizations. The premises upon which this committee formulated its recommendations are:

- The concept of "livestock production" needs to be expanded to "animal agricultural production" so that it will be considered an integral part of agriculture with primary emphasis placed on the role of livestock in overall agricultural development and income generation.
- Economic development includes income growth of the poor majority in host countries. Current production of animal products far below latent demand predisposes most developing countries to opportunities for expansion of livestock industries.
- Sustainable agriculture calls for efficient and continued production of agricultural commodities that are useful to man but do not damage the underlying resource base. Animals can have a favorable impact on the resource base when projects are carefully planned to integrate animals into agricultural production systems.
- Success of livestock programs will largely depend upon the participation of small producers.

In reviewing the outcomes of the conference, Dr. William Furtick (Director) of the Directorate of Food and Agriculture, made several observations:

"Although the Symposium built a firm case for greater donor investment in animal agriculture development, there are some basic impediments to achieving this goal. Like development in general, agricultural development progress is slow to show major impact. Donor administrators are under constant pressure to demonstrate results in the short term. Animal research and development, by its very nature, tends to be both more expensive and slower to show results than with most crops. This gives an inherent bias toward purely crop research.

"Another impediment is the long-standing disciplinary fragmentation that has been the result of departmentalization. Most of animal agriculture is part of a mixed farming system that requires cross-disciplinary efforts to effectively address. This is counter to the organizational structure under which both government organizations operate and also the way donors tend to organize. An example of the problems that result from lack of interdisciplinarity dominates much of the history of donor efforts in animal agriculture. Until recently, partly because of the magnitude and diversity of animal diseases in developing countries, veterinarians were sent to lead the animal agriculture efforts. In many cases, the diseases were the outgrowth of inadequate nutrition or management, but were the only things being treated.

"In the past decades, donor activities, especially those of the international agricultural research centers, have greatly advanced our knowledge of what can be done and what should be done. Unfortunately, this new base upon which solid progress can be made has come at a time when donor budgets have plateaued or started to decline. This means that the developing countries will need to do more with minimum support.

"The bright side of this picture is that the level of staff development in many countries has reached the point that much can be done with minimum outside help. Building networks to provide rapid flow of experiences and divisions of work therefore will become an important element in the implementation of new initiatives."

THE POLITICAL AND ECONOMIC CONTEXT FOR DEVELOPMENT OF ANIMAL AGRICULTURE IN DEVELOPING COUNTRIES*

John W. Mellor
International Food Policy Research Institute

ABSTRACT

Animal agriculture should be an important element in USAID's efforts to eliminate poverty and hunger in developing countries. Expansion of animal agriculture can enable smallholder producers to intensify their agricultural efforts even on low-productivity resources. Given adequate infrastructure and institutional structures for research, extension, and education, it is optimally a labor-intensive enterprise, and has vast potential for providing employment and incomes to the most poor. Ultimately, growing incomes will create rapid increases in livestock demand, pushing production levels beyond the ability of domestic sources to provide feed inputs, and thereby generating increased demand for cereal imports from developed countries. However, these mutually beneficial results require cooperative efforts to provide a more favorable macroenvironment for livestock production, including ongoing structural adjustments in developing countries and liberalized trade regimes in developed countries. Increased technical assistance on the part of USAID in regard to education and technology developing in livestock production and increased support for infrastructure development in rural areas could be highly influential in providing an important, growing market for U.S. exports, and more importantly, reducing poverty and hunger in developing countries.

INTRODUCTION

It is important that the United States Agency for International Development return to a greater emphasis on the development of animal agriculture in developing countries. Animal agriculture has important, useful interactions with the environment which should not be ignored. It also has important social implications because it offers an opportunity for very poor people with little or no access to land to effectively increase the size of their agricultural business. This has particularly important implications for very poor women. Very poor people on low-productivity land can obtain an increase in their incomes through animal agriculture which otherwise might not be possible by intensification of agriculture on the poor resources on which they work. That ability to overcome poor resource redowments makes animal agriculture especially relevant in many parts of Africa. It is worth noting that in the low-productivity, animal agriculture areas of Africa, the principle input of the family is not land, which has relatively little value in such circumstances, but labor. In that sense, African farmers do not differ greatly from the landless laborers of Asia.

USAID turned away from an emphasis on animal agriculture in the late 1960s and early 1970s when foreign assistance programs shifted their focus in the direction of relieving absolute poverty. There was a misguided impression that the products of animal agriculture were consumed largely

* I am grateful for comments and data from J.S. Sarma, Darunee Kunchai, and Harold Alderman; and to Frank Riely for his assistance in overall preparation of the paper.

by higher-income people and, therefore, that it was improper to emphasize those products if the primary concern was with the poor. Although it is correct that the poor obtain a much smaller proportion of their calories from animal agriculture, it is also the case that they earn a substantial amount of their income by producing animal agriculture products. Thus, a focus on poverty must give considerable attention to animal agriculture and its various products as a source of income.

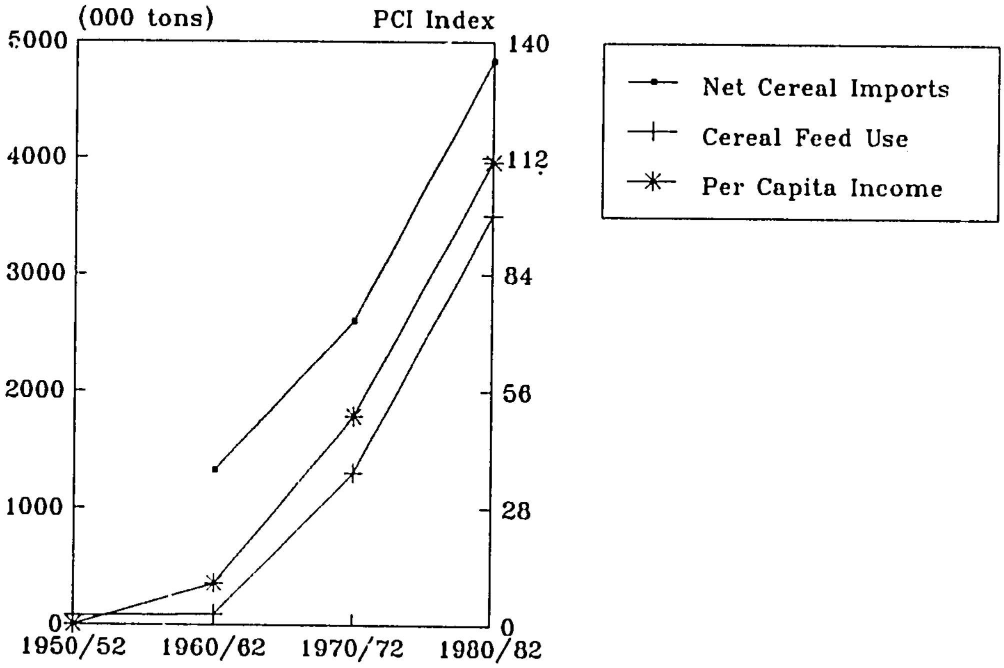
Although the main focus of foreign assistance is quite properly on how the development process may be initiated in developing countries and, even more importantly, how the poor may participate in that process, the profound implications of Third World economic development and, specifically, the development of animal agriculture, to the interests of American agriculture should not be overlooked. We should be careful not to ignore the interactions between the very processes which decrease poverty in developing countries and increase the market for major American agricultural products. Those interactions are especially striking in the case of animal agriculture. Because the poor are particularly lacking in land resources, there is much to be said for intensifying the use of those resources through increased animal production. Effort of that type results in an expanding use of livestock feed. Since developing countries are in general short of cereal production capacity -- the demand for which is growing rapidly from both population growth and rising incomes -- it is natural that they should increase their feed imports to service an intensifying livestock industry.

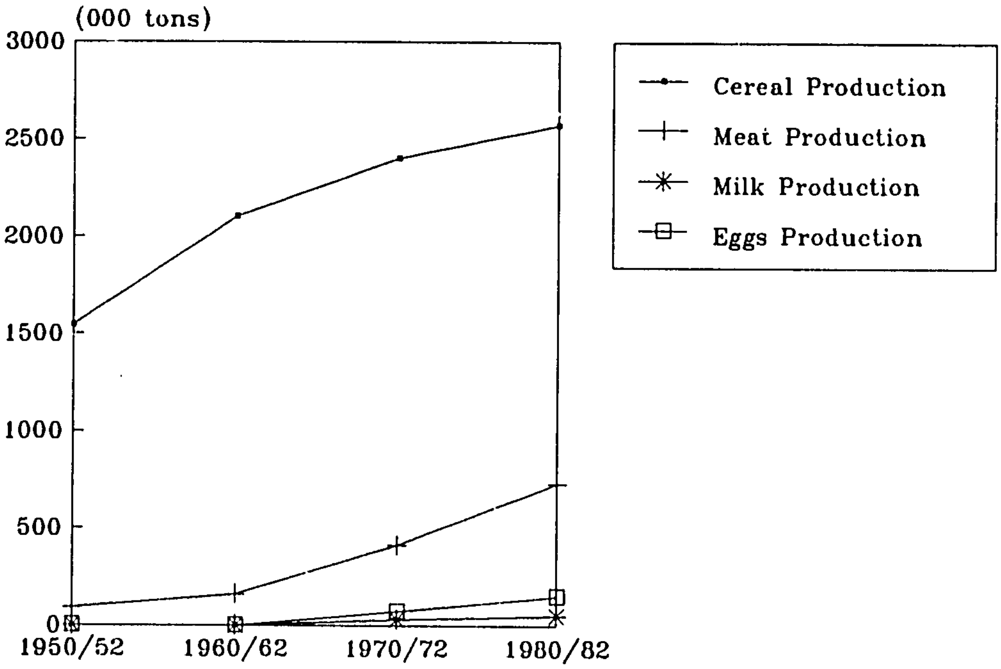
It is important to note that the demand for feed is highly elastic with respect to the rate of growth of the livestock industry. In other words, with rapid growth in the demand for livestock commodities and, therefore, growth in livestock production, the demand for feed quickly outruns the capacity to provide by-products and waste products as feed. In the underdeveloped livestock industry of low-income countries, the bulk of livestock feed comes from these sources which have little scope for dramatic increases in supply. Thus, rapid growth in the livestock industry will quickly outdistance the supply of those goods.

Increased domestic production, therefore, requires switching to feed sources that are more elastic. One way of doing so is to divert area from cereals production to high-quality forage production. That, of course, happens on a substantial scale. However, such area diversion to forage reduces the supply of cereals and also pushes towards cereal imports. Similarly, one may move directly to importing feedgrains. We note this particularly in the case of a country like Taiwan. Taiwan, which has been highly successful in agricultural production growth, has shifted during its period of rapid growth from being a modest exporter of cereals to importing 60% of all the cereals consumed (Fei, Ranis, and Kuo, 1979). Most of the cereals imported are feedgrains for the rapidly growing livestock industry which primarily serves the domestic market and which has risen as a result of rapid growth in incomes through the development process (Figure 1).

Growth in livestock production (Table 1) has contributed to greater imports of feedgrains in a number of other countries as well (Table 2). In Malaysia, another country which has converted rapid income growth into almost 12% rates of growth of livestock production, growth in net imports of coarse grains averaged 16% annually from the mid-1970s to the mid-1980s. A major exporter of vegetable oils, Malaysia is also a large importer of soybeans, not for the vegetable oil itself but for the oil cake which is so important as a livestock feed. Thailand, another country in which incomes have grown extremely rapidly, has had similar developments in its livestock industry. In that case, Thailand's cereal exports have grown much less rapidly than would otherwise have been the case.

Figure 1. Interaction of growth in the livestock sector with the global cereal economy, Taiwan, 1950/52 to 1980/82





Source: Sarma (1986).

Table 1. Total meat production and average annual growth rates in developing countries, 1961-65, 1973-77, and 1983-85 averages

Region/Country	Meat production (000 t)			Growth rate (%)		
	1961-65 Average	1973-77 Average	1983-85 Average	61-65-73/77	73-77-83/85	61/65-83/85
Asia (excluding China)	3,422	4,758	n.a.	2.785	n.a.	n.a.
India	626	726	1,128	1.240	5.021	2.843
Indonesia	326	393	666	1.581	6.032	3.465
Korea, Republic of	98	230	716	7.429	13.419	9.957
Malaysia	80	135	363	4.450	11.611	7.461
Philippines	389	643	793	4.271	2.358	3.447
Thailand	330	439	878	2.408	8.019	4.776
Others	1,574	2,193	n.a.	2.800	n.a.	n.a.
North Africa/Middle East	1,911	2,876	n.a.	3.464	n.a.	n.a.
Egypt	257	355	514	2.707	4.209	3.348
Iran	240	463	706	5.619	4.799	5.267
Turkey	535	767	925	3.039	2.107	2.638
Others	879	1,292	n.a.	3.267	n.a.	n.a.
Sub-Saharan Africa	2,181	2,875	n.a.	2.329	n.a.	n.a.
Kenya	144	201	241	2.819	2.009	2.471
Nigeria	294	367	775	1.865	8.680	4.732
Tanzania	123	167	218	2.538	3.028	2.748
Others	1,620	2,141	n.a.	2.350		
Latin America	8,065	11,510	n.a.	3.009	n.a.	n.a.
Argentina	2,706	3,146	3.353	1.263	0.712	1.027
Brazil	2,197	3,640	4,657	4.294	2.777	3.641
Mexico	791	1,279	3,047	4.090	10.125	6.635
Others	2,371	3,446	n.a.	3.165	n.a.	n.a.
Total Dev. Countries (excluding China)	15,579	22,019	n.a.	2.925	n.a.	n.a.

n.a. = not available.

Sources: Sarma and Yeung (1985); FAO (1988).

In the case of Africa, we should not expect to see much growth in demand for imported feed for livestock because incomes are generally so low. Surprisingly, however, we find in Africa that the marginal budget share of livestock commodities seems to be much higher at lower levels of

Table 2. Average net imports of coarse grain, developing countries, 1961-65 to 1983-85

	Total net imports (t)			Average annual growth rates (%)		
	1961-65	1973-77	1983-85	1961-65 to 1973-77	1961-65 to 1983-85	1973-77 to 1983-85
Asia (excluding China)	(239,400)	141,400	3,137,333	n.a.	n.a.	41.1
India	137,800	525,600	(800)	11.8	n.a.	n.a.
Indonesia	0	(59,400)	43,000	n.a.	n.a.	n.a.
Korea, Republic of	205,400	1,101,400	3,866,333	15.0	15.0	15.0
Malaysia	116,000	276,800	1,064,333	7.5	11.1	16.1
Philippines	600	115,800	356,667	55.0	35.6	13.3
Thailand	(732,400)	(2,095,600)	(2,994,667)	9.2	6.9	4.0
Others	33,200	275,800	802,467	19.3	16.4	12.6
North Africa/Middle East	800	1,404,200	11,135,000	86.4	57.5	25.9
Egypt	267,800	440,000	1,502,000	4.2	8.6	14.6
Iran	21,000	351,800	1,233,333	26.5	21.4	15.0
Turkey	(41,400)	(64,000)	(79,666)	3.7	3.2	2.5
Others	(246,600)	676,400	8,479,333	n.a.	n.a.	32.4
Sub-Saharan Africa	(82,400)	(93,400)	1,511,000	1.0	n.a.	n.a.
Kenya	(1,400)	(111,800)	147,334	44.1	n.a.	n.a.
Nigeria	18,600	6,600	241,667	(8.3)	13.0	49.2
Tanzania	1,200	131,000	155,667	47.9	26.1	1.9
Others	(100,800)	(119,200)	966,332	1.4	n.a.	n.a.
Latin America	(3,674,000)	(4,843,400)	(648,333)	2.3	(7.9)	(20.0)
Argentina	(3,811,200)	(7,888,400)	(10,569,333)	6.2	5.0	3.3
Brazil	(210,400)	(988,600)	509,667	13.8	n.a.	n.a.
Mexico	(25,200)	1,980,200	5,784,667	n.a.	n.a.	12.6
Others	372,800	2,053,400	3,626,666	15.3	11.4	6.5
Total Dev. Countries (excluding China)	(3,995,000)	(3,391,200)	15,135,000	(1.4)	ERR	ERR

n.a. = not available.

Note: Coarse grains consist of barley, maize, millet/sorghum, oats, rye, and other cereals. Numbers in parentheses are negative, or net exports.

Source: USDA (1987).

income than is the case in Asia, implying that even slight increments to income can have a relatively large impact on demand there. Hazell and Roël (1983) indicate that the marginal budget share for beef in rural Nigeria was over three times that of a similar region in Malaysia, despite higher overall incomes in Malaysia. In fact, African countries which have experienced rapid income growth over the last few decades, such as Nigeria, have demonstrated particularly rapid growth in the production of livestock and, consequently, in the demand for livestock feed. Annual growth in Nigeria's livestock production was nearly 9% from the mid-1970s to the mid-1980s and has vastly outpaced the ability to supply that livestock with feed from traditional sources. As a consequence of increased livestock consumption and shifting consumption patterns overall, imports of coarse grains have grown by 49.2% annually in the same period.

It is often suggested that the .pid growth in poultry and pig production is a major factor explaining rapid growth in the use of cereals as livestock feed. It may be, however, that the causality in this relationship is reversed. Perhaps it is the inability of traditional sources of feed to keep pace with the rapid growth in demand that induces a switch to cereals and, in the switch to cereals, induces a switch to the types of livestock which are the more efficient converters of cereals into meat. That scenario applies most importantly to poultry, but also to pigs and certain other types of livestock.

It should already be clear that the critical element with respect to how quickly the livestock industry can grow is the rate of growth of per capita income. To a much greater extent than with respect to other items of food, livestock demand is driven more by rising incomes than by population growth itself. Thus, the future of animal agriculture depends on the development process generally and, in particular, on the participation of the mass of people in that process through increases in their per capita incomes. Economic growth is essential to a prosperous livestock industry.

If we want to know what kind of a future there is for animal agriculture, we must then be concerned with the course of the global economy over the next few decades. It is only after we understand the potential of the global economy that we can then turn our minds to the difficult problems of how the livestock industry can respond to the global economic environment.

THE GLOBAL ENVIRONMENT FOR INCOME AND LIVESTOCK PRODUCTION

The 1990s have the potential for being a golden age of economic development. That potential is evident in the rapid progress of developing cou-tries in the late 1960s and 1970s which, in the 1980s, was set back by major structural maladjustments. These maladjustments include, of course, the debt crisis which is still very much with us and tremendous distortions of price relationships arising partly from the oil crisis and the rapid global price inflation of the 1970s and partly from misguided government policies. The adjustment to these changes, countering misguided policies of developing countries and donors alike in misallocating capital and underemphasizing the role of the private sector and markets in the development process, has taken much of the 1980s. Fortunately, tremendous progress has now been made in dealing with those problems.

The countries which have consistently pursued reasonably good economic policies have been able to maintain moderately rapid growth in spite of the distortions of the 1980s. Thailand and Malaysia, for example, managed rates of Gross Domestic Product (GDP) growth approaching 5% annually between 1980 and 1986 (World Bank, 1988). Under those circumstances, per capita incomes grow rapidly and are converted into rapid growth in livestock demand. In India, on the order of a hundred million people are experiencing income growth which is doubling their real incomes every 10 to 15 years. That income growth has produced extraordinary growth in demand for poultry in particular.

Development is primarily a matter of increasing the supply of human capital and organizing that human capital in institutions which can be effective from a development point of view. Even during the poor growth period of the 1980s, virtually all developing countries have been investing in education at a rapid rate, increasing the supply of human capital, and gradually developing institutional structures needed to mobilize that capital. That human capital and those structures exist currently to provide for faster growth in the 1990s, not only compared to the 1980s, but compared to the 1960s and 1970s as well. All that is required in addition is the appropriate adjustment to global and national macroenvironments.

Our greater understanding of development processes should enable us to tune human capital and institutions to reach economic objectives more efficiently than was possible in the 1960s. Now it is widely recognized that agriculture must be the basis for rapid growth in the economy of developing countries that are largely agricultural, and we understand much more fully the role of technology and the role of rural infrastructure in pursuing agricultural development. We also understand much more fully the kinds of policies that are needed so that accelerated growth in agriculture can be converted efficiently into accelerated growth in other sectors of the economy, particularly in labor-intensive sectors which are so essential to increasing employment and the prosperity of lower-income people.[1]

To realize the potential of the 1990s to produce more rapid income growth in developing countries and, as a consequence, to produce rapid growth in the demand for the products of animal agriculture, there must be open-trading regimes in world markets. That is not because development must be led by export demand, however. The basic source of demand-led growth in developing countries must come generally from their own domestic markets. Nevertheless, it is critical for them to be able to import capital-intensive goods and services, like fertilizer and various intermediate products, to free their own capital to intensify domestic labor use by spreading capital throughout the rural, smallholder sector. But, in order to import capital-intensive items, developing countries must be able to export more. In this context, the critical role of United States' policies must be recognized. In spite of its declining importance since the 1950s, the United States is still the largest single actor in the global economy and in global trade. It is critical that the United States not lead the world back into trade isolationism. It must provide leadership in opening the world economy so that, in this crucial period of the next few decades, developing countries can realize their comparative advantage in agriculture, and animal agriculture specifically, and in labor-intensive manufacturing in order to import the goods and services vital to economic progress.[2]

It is also important that there be leadership in the international organizations and from the major bilateral donors along the lines that have been set out so clearly in the 1970s and 1980s. Leadership towards more open economies, greater market orientation, and greater development of the private sector is particularly important for the rapid growth of the small-scale sectors in agriculture and in nonagriculture. It is in these sectors that growth is crucial to expand employment and to provide the broadest participation in the development process.

At the same time that we emphasize the importance of world markets that are less directly controlled by governments, we must also recognize that governments do have a very important role to play in facilitating the working of markets and the development of the private sector. Where traditions and institutions that underlie a market economy are not fully developed, as in

[1] A large body of literature discusses the linkages between growth in agricultural and nonagricultural sectors. See, for example, Mellor (1976) and Mellor and Lele (1973).

[2] The proper role of trade policy as part of an overall strategy of agricultural development is discussed more fully in Mellor and Johnston (1984), and in Mellor and Lele (1975).

many developing countries, governments must make massive investments, for example in education and in the building of rural infrastructure. Finally, we must recognize that technological development, particularly in agriculture but in other sectors as well, is absolutely critical to global prosperity. Of course, the implications of developed countries' control of a high proportion of the world's technology capability must also be recognized in the form of technical assistance to developing countries.

If the world responds well to the opportunities opening up to it in the 1990s, what policies are required in the livestock sector itself?

REQUIREMENTS FOR LIVESTOCK DEVELOPMENT

As we discuss requirements for livestock development, it is important to recognize that it is not inevitable that the livestock industry, or even livestock consumption, will expand rapidly with growing incomes. Yes, the income elasticity of demand and the marginal budget shares of livestock commodities are very high, but the price elasticity of demand is also high (Table 3). That means that if livestock prices rise relative to other prices, consumers in developing countries will switch their consumption patterns away from livestock commodities to other, perhaps even nonfood, commodities. This has occurred frequently in the past. Rapidly growing livestock consumption is not essential to human well-being. It is only desirable.

Why would livestock prices rise relative to other prices? One reason would be the existence of bottlenecks to the increased production and marketing of livestock commodities. Then, as demand increases, a sluggish supply response will raise the relative price of livestock commodities, switching consumption to other sectors.

In this context, it is important to recognize that the small-scale production of livestock commodities is the lowest-cost, most efficient in developing countries, but only if a favorable environment can be provided for small farmers. However, small-scale production takes place in rural areas which may be isolated through poor infrastructure. Furthermore, technological change in the small-scale sector is much more complex and requires much more government assistance than in the large-scale sector. If, for these and other reasons, the small-scale sector cannot respond to increased demand, there will be a tendency for the large-scale sector to develop on the periphery of urban areas. That is where the infrastructure is located initially, so those constraints are less important. In addition, the large-scale sector can provide its own technological assistance. In fact, a common situation in developing countries, particularly in poultry, pigs, and even milk production, is that production takes place on very large-scale units in the periphery of urban areas. That is not the most economic way to approach livestock production from the point of view of the overall economy. However, it may be the most economic way to do it if governments fail to do their part.

There are four critical elements to small-scale livestock production: research and extension, education, feed provision, and infrastructure.

There is a view that livestock technology is more easily transferred to developing countries than crop technology. Similarly, only a few decades ago it was believed that crop technology, including hybrid corn varieties, could be easily transferred from the central United States into the

Table 3. Price and income elasticities for livestock products, various countries

Region	Milk		Beef	
	Income elasticity	Price elasticity	Income elasticity	Price elasticity
Pakistan[a]				
Urban	1.05	-0.76	1.30	-1.01
Rural	1.37	-1.06	1.51	-0.29
Bangladesh[b]				
Poorest quartile	2.52	-1.08	-	-
Richest decile	1.91	-0.25	-	-
Sri Lanka[c]				
Urban	1.69	-1.57	0.76	-1.11
Rural	1.69	-1.38	0.76	-1.11
India[d]				
Rural	0.53	-0.99	0.80	-0.09
Brazil[e]				
Urban	0.73	-	1.45	-2.35
Rural	2.27	-	1.22	-2.35
Thailand[f]	-	-	0.41	-1.23
Colombia[g]	0.77	-0.77	0.84	-0.84
Dominican Republic[h] (at "poverty" line)	0.74	-0.37	0.62	-0.76
Egypt[i]				
Urban (poorest quartile)	1.57	-0.88	1.58	-2.88
Rural* (poorest quartile)	0.16	-0.50	1.13	-2.16

Sources:
[a] Alderman (Forthcoming).
[b] Pitt (1983).
[c] Sahn (1988).
[d] Alderman (1987).
[e] Gray (1982).
[f] Trairatvorakul (1984).
[g] Pinstrup-Andersen *et al.* (1976).
[h] Musgrove (1985).
[i] Alderman and von Braun (1984).

* In rural Egypt, fluid milk is seldom used. Income and price elasticities for cheese are 0.63 and -0.92, respectively.

tropics. However, it soon became obvious that such transfers were either not possible or not effective. Can we be so sure that livestock technology will be so easily transferred?

At least for crop agriculture, the borrowing of research results from abroad is closely related to the expenditure on research in the receiving country. It may be safe to assume that this relationship holds for animal agriculture as well. Therefore, the latest research results in, for example, poultry management and disease prevention will be difficult to transfer from the United States without a strong indigenous poultry research system. The same should be true for other livestock commodities as well.

The profound implications of inadequate agricultural research systems on crop production can be illustrated by the example of Nepal. Lack of coordination of research institutions, combined with agricultural research expenditures which dropped from 32% of the total agriculture budget in 1970/71 to only 14% in 1980/81, are a major reason for the agriculture sector's poor performance there (Yadav, 1987). Without adequate technical backup, even rapid growth in expenditure on extension services could not deliver yield growth. In stark contrast to the experience of neighboring India, yields of maize and rice have actually declined, indicating the inability of the indigenous research system to effectively adapt that new technology. Similarly, Nepal's low productivity in animal agriculture, due in part to low genetic potential, widespread disease, and inadequate management, ultimately stems from inadequate research systems.

Therefore, we conclude that it is essential that much more be done in developing livestock research systems if we expect to make substantial progress in livestock production.

Livestock management is a complex process and, therefore, requires a particular emphasis on education. Alderman (1987) indicates that the acceptance of crossbred animals in Central India is strongly related to farmers' education level, particularly to those who have good secondary school education. Crossbred animals do seem to be more productive and profitable in India if they are managed properly, but the management systems they require are highly refined. It would appear that only the well-educated farmer is able to adopt those systems (see also Mergos and Slade, 1987).

Similarly, Alderman finds that there is a functional relationship between the level of education and the intensity of livestock feeding, particularly in the use of feed concentrates. Use of high levels of feed inputs probably pays only if the overall management system is highly developed. Thus we conclude that education is very important to the growth of a technically efficient livestock industry. There is undoubtedly a complex interaction between level of education and the effectiveness of the extension system. On the one hand, well-educated farmers can probably benefit more from good technical extension than ill-educated farmers. On the other hand, there is probably some scope to speed up the processes of technological improvement in animal agriculture beyond what existing levels of education will allow through a well-developed extension system. Given the complexity of management problems, however, extension needs to be technically competent.

The emphasis on increasing the intensity of livestock production should not lead to neglect of the importance of improved pastures and improved extensive agriculture. It is only to say that, in land-short countries with rapid growth in demand for livestock products and with labor readily available for expanding that production, it is particularly important to look at intensifying processes.

If feed use is to be intensified, there must be considerably more expenditure on developing feed processing industries and making its product available to small farmers. Some will claim that more intensive livestock production systems can only be taken up by large-scale farmers and that, with the small farmers, one must stay with old-fashioned, low-intensity techniques. That was an argument put forward with respect to high-yielding crop varieties some decades ago, and it was shown to be absolutely false if farmers are given access to credit, purchased inputs, and the other necessities which big farmers can provide for themselves. Government is very important to assist small farmers in their efforts to intensify crop production. That fact is just as true for livestock as it is for crops.

Finally, we must emphasize the role of infrastructure in the development of the livestock sector. To encourage increased output of bulky and highly perishable livestock products, farmers must have easy access to markets to minimize the threat of losses and to ensure the availability of inputs. Ahmed and Hossain (1987) show, in the case of Bangladesh, that when infrastructure is well-developed, livestock contributes a substantially larger share to household incomes than in underdeveloped areas. Livestock contributes 9% to total household incomes in the developed regions as opposed to 6% in the underdeveloped areas. The difference in absolute income from livestock production between households in two regions was 48%. Improved infrastructure plays an extraordinarily important role, not only in the development of animal agriculture generally, but in growth in employment and increased incomes of the poor as well. Again, in Bangladesh, these effects are illustrated by the fact that the share of total income in the livestock sector going to landless households in developed infrastructure areas is 74% greater than in underdeveloped areas; whereas, the difference in the proportion of landless between the two areas is only 9%. In addition, the cumulative effect of well-developed infrastructure on incomes also interacts back on consumption, influencing the demand response for livestock products. The marginal budget share for livestock products is 53% higher in Bangladesh's developed areas.

CONCLUSION

The development of animal agriculture is a crucial element in strategies designed to eliminate poverty and hunger in developing countries. It is important, not because of insufficient supplies of livestock products *per se*, but because livestock production is optimally labor-intensive and can provide employment and incomes to the poor, enabling them to purchase more food. Under the proper circumstances, given adequate government involvement in supplying infrastructure and developing institutional structures for research, extension, and education, animal agriculture can be used to intensify smallholder production in spite of their often poor resource base. In this way, animal agriculture expands income growth to the broadest possible segment of developing country populations.

Widespread income growth in developing countries will, in turn, generate rapid increases in livestock demand, as the poor shift their consumption to higher quality foods. Ultimately, growing demand for livestock products will require greater imports of cereals to meet increased feed consumption. Therefore, growth in animal agriculture in developing countries has important, advantageous implications for developed country cereal exporters, particularly including the United States.

Recognizing the potential importance of animal agriculture in regard to both poverty alleviation and its own domestic constituency, the United States should focus on the following priorities to assist in the development of the Third World livestock sector. First, it should reduce barriers to trade in the labor-intensive products in which developing countries possess a comparative advantage. Second, it should provide technical assistance in research and education to facilitate the development and transfer of livestock production and marketing technologies and to provide small farmers with more sophisticated management techniques. And, finally, it should provide added assistance in the building of rural infrastructure to facilitate small farmers' access to markets for inputs and their output.

As the process of structural adjustment works its way through in the developing countries, supported by enlightened foreign assistance policies, tremendous strides can be made against poverty. Such progress will occur, however, only with an understanding of the role of agriculture, and animal agriculture in particular, in the overall development process. Success in those efforts will ensure that the developing countries will enjoy rapid economic growth through the 1990s and beyond.

REFERENCES

Ahmed, R., and M. Hossain. 1978. *Infrastructure and Development of a Rural Economy.* International Food Policy Research Institute, Washington, DC.

Alderman, H. 1987. *Cooperative Dairy Development in Karnataka, India: An Assessment.* IFPRI Research Report No. 64 (December). International Food Policy Research Institute, Washington, DC.

________. Estimates of consumer price responses in Pakistan using market prices as data. *Pakistan Development Review.* (Forthcoming).

Alderman, H., and J. von Braun. 1984. *The Effects of the Egyptian Food Ration and Subsidy System on Income Distribution and Consumption.* IFPRI Research Report No. 45 (July). International Food Policy Research Institute, Washington, DC.

Fei, C.H., G. Ranis, and S.W.Y. Kuo. 1979. *Growth with Equity: The Taiwan Case.* New York, NY: Oxford University Press for the World Bank.

Food and Agriculture Organization of the United Nations. 1987. *Standardized Commodity Balances for Livestock Products.* FAO, Rome.

1988. Standardized Commodity Balances for Livestock Products. FAO, Rome.

Gray, C.W. 1982. *Food Consumption Parameters for Brazil and their Application to Food Policy.* IFPRI Research Report No. 32 (September). International Food Policy Research Institute, Washington, DC.

Hazell, P.B.R., and A. Roell. 1983. *Rural Growth Linkages: Household Expenditure Patterns in Malaysia and Nigeria.* IFPRI Research Report No. 41 (September). International Food Policy Research Institute, Washington, DC.

Mellor, J.W. 1976. *The New Economics of Growth.* Ithaca, NY: Cornell University Press.

Mellor, J.W., and B.F. Johnston. 1984. The world food equation: Interrelations among development, employment, and food consumption. *Journal of Economic Literature* 22 (June):531-574.

Mellor, J.W., and U. Lele. 1973. Growth linkages of the new foodgrain technologies. *Indian Journal of Agricultural Economics* 23 (January-March):35-55.

_______. 1975. The interaction of growth strategy, agriculture, and foreign trade: The case of India. In *Trade, Agriculture, and Development*, edited by G.S. Tolley and P.A. Zadrozny. Cambridge, MA: Balinger Publishing Co.

Mergos, G., and R. Slade. 1987. *Dairy Development and Milk Cooperatives: The Effects of a Dairy Project in India*. Discussion Paper 15. World Bank, Washington, DC.

Musgrove, P. 1985. Household food consumption in the Dominican Republic: Effects of income, price and family size. *Economic Development and Cultural Change* 34 (October):83.

Pinstrup-Andersen, P., *et al.* 1976. The impact of increasing food supply on human nutrition: Implications for commodity priorities in agricultural research and policy. *AJAE* 58 (May):131-142.

Pitt, M. 1983. Food preferences and nutrition in Bangladesh. *Review of Economics and Statistics* 65 (February):105-114.

Sahn, D. 1988. The effect of price and income change on food-energy intake in Sri Lanka. *Economic Development and Cultural Change* 36 (January).

Sarma, J.S. *Cereal Feed Use in the Third World: Past Trends and Projects to 2000.* IFPRI Research Report No. 57 (December). International Food Policy Research Institute, Washington, DC.

Sarma, J.S., and P. Yeung. 1985. *Livestock Products in the Third World: Past Trends and Projects to 1900 and 2000.* IFPRI Research Report No. 49 (April). International Food Policy Research Institute, Washington, DC.

Trairatvorakul, P. 1984. *The Effects on Income Distribution and Nutrition of Alternative Rice Price Policies in Thailand.* IFPRI Research Report No. 46 (November). International Food Policy Research Institute, Washington, DC.

United States Department of Agriculture. 1987. *Production, Supply, and Distribution Tape, 1987.* USDA, Washington, DC.

World Bank. 1988. *World Development Report, 1988.* New York, NY: Oxford University Press.

Yadav, R.P. 1987. *Agricultural Research in Nepal: Resource Allocation, Structure and Incentives.* IFPRI Research Report No. 62 (September). International Food Policy Research Institute, Washington, DC.

CROP-LIVESTOCK INTERACTIONS AFFECTING SOIL FERTILITY IN SUB-SAHARAN AFRICA

John McIntire
International Livestock Center for Africa

INTRODUCTION

Manure to improve soil fertility is a major benefit of crop-livestock integration. It is thought to be an input whose quantity could be increased greatly, whose value could be improved by simple techniques, and whose use could improve soil productivity and structure. Used with chemical fertilizers, manure might provide additional elements -- its so-called specific effect -- (Padwick, 1983; Mokwunye, 1980; Pieri, 1985), raise soil pH, and permit stable intensified cropping systems. Research from different African sites has confirmed that manure raises yields and improves soil organic matter content (Jones, 1971 for Nigeria; McWalter and Wimble, 1976 for Uganda; Pichot *et al.*, 1981 for Burkina Faso), but has weakened the hypothesis of a specific effect.

Many farm management studies, as well as the field visits reported here, have shown that manure is employed on small areas, and sometimes not employed at all. Where it is used, it is used in an agronomically inefficient way; it is rarely stored, mixed with litter, composted, or incorporated to reduce losses of dry matter (DM) and of nutrients (Kwakye, 1980) to leaching, to evaporation, and to microbial action.

The apparent conflict between experimental work and farmers' practice can have many explanations. It is possible that farmers do not value manure, that other soil amendments, such as chemical fertilizers and mulches, have displaced manure, or that the economics of intensifying manure production and use have been unfavorable. These arguments are examined in the following sections. First, estimates of yield and soil effects from manures and mulches are given. Second, they discuss field data on manure utilization by environment, and on market relations in soil fertility inputs. Third, they present a general perspective on the economics of soil fertility maintenance.

REVIEW OF EXPERIMENTS

Introduction

Experimental work has concentrated on the effects of organic matter returned to the soil by animal manuring, mulching, green manuring, and composting. The major work has been at Samaru (Jones, 1971, 1976), at Bambey (Charreau and Nicou, 1971; Ganry and Bideau, 1974); at Saria, Burkina Faso (Pichot *et al.*, 1981); at M'Pesoba, Mali (Pieri, 1973); at Tarna, Niger (Pichot *et al.*, 1974), at Serere, Uganda (McWalter and Wimble, 1976), and at the International Institute for Tropical Agriculture (IITA) in Ibadan (Okigbo *et al.*, 1980; Lal and Greenland, 1979). Table 1 summarizes some of these trials.

Table 1. Summary of selected manuring experiments

	Site							
	Bambey	**Bouake**	**Ibadan**	**M'Pesoba**	**Samaru**	**Saria**	**Serere**	**Tarna**
Reference	Ganry and Bideau, 1974	Chabalier, 1986	Okigbo *et al.*, 1981	Pieri, 1973	Jones, 1971, Jones, 1976	Pichot *et al.*, 1981	McWalter and Wimble, 1976	Pichot *et al.*, 1974
Environment	semiarid	subhumid	humid	semiarid	semiarid	semiarid	subhumid	semiarid
Crops	millet	maize	maize, cowpea, cassava, soybean	cotton, sorghum, groundnut	sorghum, maize, groundnut, cotton	sorghum	groundnut, maize, finger millet, cotton, sweet potato	millet
Organic materials	millet straw	composted maize straw	numerous mulches	manure	cattle dung, sorghum and maize straw, groundnut hulls	manure	manure	millet straw
Application	composted, incorporated	composted, incorporated	spread	unknown	incorporated	incorporated	unknown	incorporated
Material, t/ha	0,11,15	40	0,10,15,25	0,10,20	0,2.5,5.0, 7.5,12.5	0,5	0,6.3, 12.6	0,10
Fertilizers, kg nutrient/ ha	N,0,30,60,90, 120,150	N,0,40,80,120, 160,200 P,100 K,150	N,0,30,40,120 P,0,20,30,90 K,0,20,40,60	unknown	N,0-52 P,0-30 K,0-30	N,8 P,24	none	N,0,45,90 P,20 S,25
Interactions	straw x N	straw x N	mulch x N,P,K, and rotation	manure x fertilizer	manure x N,P,K, and rotation	manure x N,P	manure x rotation	straw x N

This work has concentrated on the semiarid and subhumid areas, and on their major cereals, maize, sorghum, and pearl millet. Experimental methods have consisted of plots continuously cultivated with tractors or animals, from which above-ground crop residues have been removed. Large quantities of cattle dung or mulch, usually between 5 and 10 t of fresh matter per hectare, have been applied, generally by incorporation at plowing. Moderate quantities of chemical fertilizers, between 25 and 150 kg of nutrients per hectare, are applied.

These experiments, and many others in SSA, were designed to answer some basic questions. What is crop response to manures? What are the interactions between chemical fertilizers and manures? What are the interactions between fallow and manures? What is the comparative efficiency of different organic materials in soil restitution? In most of the published work, these questions have been answered clearly, even if the quantitative evidence is not as sharp as it is for fertilizer response.

However, if these experiments were intended to produce results for extension, then some of their methods were biased, overestimated the true treatment effects, and weakened the prospects of extension. First, in comparison to farmers' practices, the fertility treatments were correlated with factors which increase yields. The outstanding examples are the timing and quantity of labor inputs, especially for soil preparation and weeding. Second, the experiments do not represent farmers' objectives; experiments maximize physical yield, and farmers maximize profits or utility. Example of this are unrealistic uses of labor or machinery in experiments. Third, control plots were often managed so as to produce bias with respect to farmers' practices. In the DNPK (dung, nitrogen, phosphorus, potassium) experiments at Samaru, crop residues were removed from the plots; because such material is an important source of organic matter on the farm, its removal from experimental controls makes them less representative. Fourth, the test quantities of organic materials are much greater than those normally used by farmers; this is a particularly serious bias in the long-term trials and makes it difficult to estimate the real advantages of manuring and fallowing as fertility strategies under farmers' conditions. Published summaries of some experiments end with the apology that such quantities are unavailable to farmers, but this insight has rarely been used in the next generation of experiments.

YIELD EFFECTS OF MANURE AND MULCHES

Manure

The best index to compare manures to fertilizers is the product/nutrient ratio, typically expressed as kg of product per kg of nutrient. It is usually impossible to present consistent results about product/nutrient ratios for organic materials; because of deficiencies in nutrient and dry matter estimates for the test materials, results are less clear than with chemical fertilizers.[1] Therefore, Tables 2 and 3 give calculated product/material ratios.

The material ratios can provide rough approximations to the nutrient ratios if they are weighted by the nutrient contents of organic materials. Padwick (1983) reviewed the maintenance of soil fertility in tropical Africa and noted the lack of information on manure in some experiments. In Burkina Faso, Pichot *et al.* (1981) found manure to contain 1.47 to 2.47% N, 0.21 to 0.24% P_2O_5, and 1.6 to 4.5% K_20, according to the year of the estimates. In Ghana, Kwakye (1980) found N contents from 0.71 to 1.48%, P_2O_5 from 0.50 to 0.60%, K_20, from 1.32 to 2.14%, and DM from 22 to 27%. McWalter and Wimble (1976) reported values in Uganda of 1.90% N, 0.89% P_2O_5, 3.58% K, and 36.1% DM.

In spite of variation in methods, the general indication is clear. Animal manures produce weak crop responses. A ton of fresh manure probably produces about 50 kg of grain in the short term. One hypothesis tested in the long-term Uganda experiment (McWalter and Wimble, 1976) was that manure would allow reduction in fallow periods, while maintaining yields, in the absence of chemical fertilizer. These experiments began in 1933 and continued until 1964. They investigated the impacts of type of fallow, length of fallow, and manure, on yields of cotton, sorghum, finger millet (*Eleusine coracana*), sweet potato, and groundnut over three different five-year rotations at three manure levels.

[1] Reporting of trial results was not uniform. Some reported fresh grain and stover yields, while some reported dry.

Table 2. Results of manuring experiments

	Site				
	M'Pesoba	Serere	Saria	Uganda	West Africa
References	Pieri, 1973	McWalter and Wimble, 1976	Pichot *et al.*, 1981	Stephens, 1969	Pieri, 1986
Response to manure, kg/mt without chemical fertilizer					
sorghum	32.4	23.2			57.8
maize				54.0	
millet					
finger millet		15.2		86.0	
cassava, fresh tubers					
groundnut	13.9			26.5	
Response to manure, kg/mt with chemical fertilizer					
sorghum	11.7		93.7		79.5
maize					
groundnut	9.1				
cassava, fresh tubers					

Notes: Blank entries in the table indicate that a response was not available or could not be calculated from the reference. Responses were generally calculated at the reported treatment means for crop yields by:

$$\frac{\text{treatment yield} - \text{control yield}}{\text{input level.}}$$

McWalter and Wimble values are in cycle 3 of their experiments at 6.3 t/ha of manure without chemical fertilizers.

McWalter and Wimble (1976) reported major results: all treatments had a declining yield trend for sorghum, finger millet, and sweet potatoes; the weight of finger millet and sorghum depressed the aggregate yield because they were high-bulk, low-value crops; the effects of manure, fallow, and type of fallow were "mainly additive" for finger millet; manure responses increased during the experiment for all crops, but this response reached an upper limit. For example, a ton of manure produced 19 to 23 kg of sorghum in cycles II and III, and 31 to 39 kg in cycles IV and V. These increased responses did not prevent long-term yields from decreasing from cycles II to V.

The low concentration of manure makes it much less efficient in terms of transport and application costs than chemical fertilizers. A ton of fresh manure, stored loosely on a grass litter, spread on the soil, and containing 0.75% N (roughly Kwakye's methods and result) would give a response of 6 to 7 kg of grain/kg of N assuming a response of 50 kg/t of material. A ton of diammonium phosphate (18-46-0), at a response of 6.5 kg grain/kg N would give 1,170 kg of grain per ton of material.

Table 3. Results of mulching experiments

	Site				
	Bambey	Ibadan	Samaru	Tarna	West Africa
References	Ganry and Bideau, 1974	Okigbo *et al.*, 1981	Heathcote, 1969	Pichot *et al.*, 1974	Pieri, 1986
Response to mulch, kg/mt without chemical fertilizer					
sorghum			43.0		-17.9, 67.4, 47.3
maize			62.2		
millet	12.0			17.5	
groundnut					
cassava, fresh tubers					
Response to mulch, kg/mt with chemical fertilizer					
sorghum		40.0, 23.5			63.1, 89.2, 80.5
maize					
millet	23.0			-10.0	
groundnut					
cassava, fresh tubers		301.3			

Notes: Blank entries in the table indicate that a response was not available or could not be calculated from the reference. Where more than 1 value is given in a cell, this means methods differed within the experiment, or that more than 1 year was reported.

Mulches

The results for crop residues and grasses are more variable. It appears that a ton of fresh incorporated crop residue produces of the order of 20 to 40 kg of grain. Pichot's (1985) summary of IRAT work reported 35 kg of sorghum grain/ton of incorporated straw at Saria, and 45 kg at Farako-Ba when 10 t were used; when 20 t were used, the gains were 18.3 and 33.3 kg/t, respectively.

Use of animal manure is impractical in the humid zone, and research there has concentrated on mulch. One series of IITA experiments at Ibadan employed 24 different mulches. Although the quantities of mulch were not standardized among materials, making strict comparisons impossible, significant responses in maize grain and fresh cassava were found to maize stover and to cassava stems, as well as to many other organic and inorganic mulches.

Experiments in the SAT with millet on sandy soils, showed a very low response of crops to residue incorporation, of the order of 20 kg of grain produced per ton of residues incorporated. In some instances, incorporating millet residues depressed subsequent crop yields, especially if it was plowed under at the end of the dry season, just before planting the next crop. Ganry *et al.* (1981) found no depressive effects of plowing crop residues (especially millet) into sandy soils in central Senegal, if the residues were composted, or plowed into damp soil just after harvest. However, postharvest plowing and composting have both been tried and rejected by farmers in central Senegal.

Jones (1976) examined crop residue experiments at Samaru, Nigeria. He found that burning or incorporating maize and sorghum improved soil quality; while the treatments had no statistically significant effects on crop yields (grain or stover), the trends in the results were obvious. It is not clear if these experiments are representative of farmers' conditions, however; they were planted at high N levels (45 and 135 kg/ha), and there might have been interactions between chemical and organic nutrients.

SOIL EFFECTS OF MANURE AND MULCHES

An important question in soil studies is the extent to which manure replaces fallow and complements chemical fertilizer. Another hypothesis, tested in the Samaru experiments, was that manure improved long-term soil quality, as measured by the C and N percentages. Experiments at Saria (Pichot *et al.*, 1981) and at Bouaké (Chabalier, 1986) tested compost effects on continuous sorghum and maize production.

The effects of cattle dung, N, P, K, and groundnut shell mulch were studied at Samaru by Jones (1971), who analyzed data collected from 1949 to 1969. His synthesis of three experiments is reproduced below. In the rotation trial, the soil carbon and nitrogen figures are the differences between values in 1961 and 1969 as a percent of the earlier measurement; in the fertility trial, the soil carbon and nitrogen figures are the differences between values in 1959 and 1967 as a percent of the earlier measurement. (In both trials, manure is thought to be in fresh matter.) The mulch trial values are dissimilar; they are the difference between the 5.0 t/ha mulch treatment and the control, as a percent of the control, at the time of soil sampling in 1970, after nine years of the trial.

	Change in C (%)	**Change in N (%)**
	Rotation trial, no fertilizers	
Manure, t/ha		
0.0	-12	-20
2.5	- 6	0
7.5	22	25
12.5	34	27
Manure, t/ha	Fertility trial	
0.0	-32	-35
2.5	-7	-19
5.0	0	-11
Mulch, t/ha	Mulch trial	
5.0	43	33

Jones concluded that the use of chemical fertilizers affected the fate of manure; soil C and N declined with 2.5 t/ha of manure, and barely stabilized with 5.0 t/ha in the fertility trial; an annual application of 7 to 8 t/ha of manure, or a planted grass fallow 3 years in 6, would maintain maximum soil organic matter; groundnut-shell mulch, "weight for weight appears to have been twice as effective as [manure in maintaining soil organic matter];" it would probably be necessary to restore some crop residues to the soil.[2]

Pichot *et al.* (1981) reported 20 years of continuous trials on sorghum at Saria in Burkina Faso. Their synthesis of the second half of the trial is presented below.[3] The soil carbon and nitrogen figures are the values in 1969 and 1978; because the trials began in 1960, the 1969 values differ among treatments.

	1969		1978	
	C	N	C	N
Control	0.29	0.0023	0.25	0.0028
8-24-0	0.29	0.0020	0.24	0.0019
+ crop residues	0.31	0.0028	0.25	0.0018
+ 5 t/ha manure	0.31	0.0029	0.35	0.0044
82-48-51	0.31	0.0027	0.24	0.0028
+ 40 t/ha manure	0.53	0.0047	0.66	0.0054

As in the Samaru trial, continuous cultivation reduced soil quality. Manure, added to a light fertilizer treatment, improved the soil, but crop residues did not. Manure with a light fertilizer application was superior to heavy fertilizer application without manure.

Chabalier (1986) studied the effects of chemical nitrogen and composted maize straw on maize yield and soil quality after 11 years work at Bouaké. The effect of compost (40 t fresh matter per hectare, or 10 t DM per hectare) was roughly 51 kg of grain per ton of compost DM, and

---

2 As previously noted, the Samaru experiments to 1967 were overestimates of the true soil effects of cropping, because residues were removed from the plots. While farmers would remove most of the above-ground residues, there would be some left after grazing and trampling. This restored residual would, in effect, add organic matter to the untreated controls and reduce the estimated treatment effects in farmers' conditions. Van Raay and de Leeuw (1971) studied two regions of northern Nigeria and showed that 34% of sorghum residues were edible, all of which were grazed. Their results imply that something like 5.2 t/ha of crop residue DM would be left after grazing.

3 The Burkina Faso results were not reported clearly. It is not known if the crop residues incorporated were removed from the previous harvest, or if they came from somewhere else. It is also unclear if the manure and crop residue weights are fresh or dry, or what the method of application is. Some of the numbers presented here were measured from graphs in the text, and might not be very precise.

had no interaction with N in the first five years of the trial; in the second 6 years, there was a strong interaction between compost and N. Chabalier argued that while compost maintained fertility for a few years after opening the field, even high levels of compost did not counter balance long-run soil degradation caused by continuous cropping, though it did attenuate it. He concluded that 40 kg N/ha with compost would give the same result as 200 kg N/ha without compost.

General conclusions from this work, conducted over many years, are:

- Manure (Uganda) or chemical fertilizer (Saria, Bouaké) alone cannot maintain fertility.
- Manure is superior to cereal crop residues (Saria, Samaru); manure might be inferior to groundnut shell mulch (Samaru).
- Composted crop residues and manure might replace chemical fertilizers in some situations (Samaru, Bouaké).
- The relative efficiency of manure and crop residues in the absence of fertilizer cannot be determined from these experiments.

YIELD EFFECTS OF CHEMICAL FERTILIZERS

Reviews of fertilizer response (Richards, 1979; McIntire, 1986) are summarized in Table 4. The responses are imperfect. First, they are estimated typically from standard treatments applied in one year at several sites. It is therefore impossible to estimate effects over time, except by assuming that site is a proxy for time. Second, standard treatments are badly adapted to different environments and so produce biased estimates; in Burkina Faso, the FAO Fertilizer Program used a standard NPK dose in a region receiving 1,100 mm rainfall per year and in a region receiving 400. It is therefore impossible to estimate interactions among land quality, cropping history, and treatment. Third, there is almost certainly selection bias in reporting, because unsuccessful trials are sometimes not reported. This eliminates low or null yields and inflates mean responses.

Perhaps most importantly, soil and nutrient interactions cause variation between environments for the same crops. Such interactions are made more complicated by the fact that response estimates are made from plots of unknown fertility or history, especially from trials on farms. For example, maize generally gives good physical responses to N (e.g., Goldsworthy (1967b), for Northern Nigeria and the FAO trials reported in FAO (1971)), but Ofori (1973), working in the forest zone of Ghana, found small and sometimes negative responses. As Ofori noted, there was an interaction between the N treatments on maize and the fertility of the test plots.

Bearing these biases in mind, the order of physical responses to N is reasonably clear. In rainfed conditions, among the four major cereals of SSA, the ranking is rice, maize, sorghum, and pearl millet. Results are less abundant for other crops, but responses have been reported for wheat, groundnut yams, cassava, finger millet, and cotton, among others.

Table 4. Fertilizer responses (kg of product/kg of nutrient)

	Maize	Millet	Paddy	Sorghum
Nitrogen applications				
Mean nutrient use, kg/ha	107	79	99	50
MPPs, kg grain/kg nutrient				
n of obs	6	30	63	36
mean	16.2	4.3	18.3	5.7
s.d.	8.2	4.1	10.9	4.9
APPs, kg grain/kg nutrient				
n of obs	6	20	63	19
mean	20.4	5.9	21.4	9.9
s.d.	4.7	3.3	8.1	5.5
FAO fertilizer trials				
Mean nutrient use, kg/ha	40	20	45	20
Response range, kg/kg	6-14	5-10	10-20	5-10
FAO fertilizer demonstrations				
Mean nutrient use, kg/ha	20	20	30	20
Response range, kg/kg	10-20	6-14	10-20	6-14
Phosphorus applications				
Mean nutrient use, kg/ha	150	NA	NA	52
MPPs, kg grain/kg nutrient				
n of obs	22	NA	NA	9
mean	10.7	NA	NA	6.7
s.d.	12.6	NA	NA	5.3
APPs, kg grain/kg nutrient				
n of obs	22	NA	NA	9
mean	12.6	NA	NA	7.0
s.d.	7.8	NA	NA	5.7
FAO fertilizer trials				
Mean nutrient use, kg/ha	20	20	20	20
Response range, kg/kg	5-12	4-8	8-15	4-8
FAO fertilizer demonstrations				
Mean nutrient use, kg/ha	20	20	20	20
Response range, kg/kg	2-8	6-15	4-12	6-15

Sources: Bono and Marchais (1966), Christenson (1981), Matlon (1984), McIntire (1983c), Poulain *et al.* (1976), Traore (1974), and Thibout *et al.* (1980).

ECONOMIC ANALYSIS OF FERTILIZERS

Physical responses do not make fertilizer profitable unless the value of the extra output exceeds fertilizer cost. A typical profitability criterion is the incremental value/cost ratio (VCR): the VCR is the additional yield from fertilizer, valued at market prices, divided by the market cost of the fertilizer. In principle, a VCR greater than 1.0 is profitable, though the FAO minimum standard is usually 2.0.

By the VCR standard, Richards (1979) found fertilizers to be generally profitable for the major crops, as well as for yam, groundnut, wheat, and teff. Couston (1971) calculated average VCRs for the best treatments in each of seven west African countries. The ranges by crop were: rice, 2.6-6.5; maize, 1.8-3.7; millet, 1.8-4.3; sorghum, one estimate of 1.8. In studies of maize in Kenya (Okalo and Zschernitz, 1971), Lesotho, and Botswana (Doyle, 1971), an average of 2.1 was estimated; for sorghum in the same countries, the average was 0.89, meaning that fertilizers would not have been profitable. In Northern Nigeria, Goldsworthy (1967a and 1967b) found profitable responses to N and P in sorghum and in maize, although the profit maximizing rates were higher in maize.

These results are generally from trials on-station or on-farm, or from on-farm demonstrations with external control. Studies on-farm, done with farmers' management and with little external control, in Niger and in Burkina Faso (McIntire, 1986) showed responses of millet and sorghum to be lower and more variable than those on-station. The conclusion is reinforced if one recalls that the responses were generally lower at application rates lower than those in experimental work. In economic terms, lower responses meant that farmers risked financial loss with recommended rates.

Allan (1971) investigated why fertilizer response on Kenyan farms might be less than on-station. Kenya is a good illustration because its agricultural research system has achieved some success in a good agroclimate. Allan identified interactions between cropping practices -- time of planting, density, cultivar -- and fertilizer use. His estimates of those interactions were negative; that is, late planting, low density, and unimproved cultivars reduced fertilizer responses to levels below those on stations.

FIELD VISITS

Crops Manured and Techniques

It was known at the outset that manure was more important than chemical fertilizers throughout Sub-Saharan Africa. It was also believed that manuring was technically inefficient, in the sense that losses occurred in collection, storage, and application. Therefore, the field visits emphasized recording current manuring and crop management practices, the use of improved techniques, and the evolution of current techniques toward improved ones, as ways of understanding the efficiency of manure use and constraints to its amelioration.

Manure use is indeed common, but is generally unimproved (Table 5). In only 7 sites (all highland save Machakos in Kenya) was manure-improved in one way or another. The main use

Table 5. Soil fertility practices observed in field visits

	Environment			
	Humid	Subhumid	SAT	Highlands
Number of sites	4	6	11	12
Chemical fertilizers				
never	2	2	2	1
none, but formerly				
main use				
food crops only	2	2	8	5
cash crops only		1	1	4
mix of food and cash crops		1		
ever use on forages?				3
overall importance where used				
rare				3
occasional	2		9	6
often		4		3
always				
Manure				
never	2	2		
none, but formerly				
main use				
food crops only		2	11	5
cash crops only				
mix of food and cash crops		1		4
ever use on forages?				2
overall importance where used				
rare	2	1		3
occasional			5	2
often		3	6	1
always				6
main types				
paddocking		4	7	0
stall	2	1	4	6
compost				3
improved production techniques				
mix with soil				
mix with litter			1	7
application techniques				
spread	2	4	11	8
incorporate				3
burn				1

of manure was on food crops, but this finding is selectively biased. Availability of fertilizer is sometimes tied to development projects which require its use on cash crops. Many sites were in the SAT where the cropping pattern is limited, largely by rainfall, to food staples, thus leaving little option for manuring of cash crops.[4]

The spatial pattern of manure use, stratified by environment, fits the classic pattern. In sparsely populated areas (e.g., the West African SAT) intensive manuring was found only on fields near the compounds, and on distant fields where cattle can be paddocked. In densely populated areas (e.g., the Kenyan highlands) intensive manuring is general. The difference is caused by transport costs and animal access to fields. Transport costs limit manuring, by any means other than paddocking, to near fields in the sparsely populated areas, but their sparse population allows intensive manuring by paddocking on distant fields. Transport costs of manure are much lower in densely populated areas because fields are nearer, but paddocking is impossible because of permanent cultivation and the risk of crop damages.

The contrast between manuring techniques in the field visits and in the review of manuring and mulching experiments is instructive. With the exception of Ofori's (1973) work in Ghana, manuring, mulching, and composting involved turning organic matter under with tractors or animals. We found no examples in the field visits of tractors being used to incorporate organic matter; even in Machakos, where improved manure production is known and where there is a tractor rental market, manuring consisted only of surface application. In areas with general animal traction (the Zimbabwe sites, Machakos, Kianjasoa), oxen were never used to incorporate crop residues or manures. In areas without general animal traction, but where manuring is common (Niger and Burkina Faso), there was no hand incorporation, only paddocking. The contrast between research and farm practice suggests not only that the experiments are unrepresentative, but that they have overestimated crop response to organic matter, since it is known (Kwakye, 1980; Hamon, 1972) that storage technique affects manure quality.

Markets and Contracts

Given the small, but well-known and easily identifiable crop response to manure, the absence of transactions in manure would suggest that farmers placed no value on it. This would imply that greater manure use is at least partly constrained by lack of information. The field visits therefore emphasized the investigation of manuring interactions, especially between different production units and ethnic groups, to see what value, implicit or explicit, was placed on manure and its substitutes.

Exchanges involving manures were common at all but the humid sites (Table 6). The exchanges almost never involved markets (the exception was the Kenya highlands, which is a very special case), exchanges over distances, or cash payments. These restrictions on the types of transactions are easy to understand. Manure is a low-value, high-bulk, partly perishable commodity which naturally tends to be nontraded.

Exchanges were most common in the West African subhumid and semiarid tropics, as has been observed repeatedly in the literature.

[4] The field visits and the literature review did find intensive manuring of cash crops in peri-urban areas of the SAT.

Table 6. **Manure exchanges observed in field visits**

	Environment			
	Humid	Subhumid	SAT	Highlands
Number of sites	4	6	11	12
No exchanges	4			
Exchanged mainly for				
grain		1	4	
water			2	
crop residues		2	1	7
labor			1	
grain plus crop residues		1	1	
transactions for				
cash		3	7	7
land				

Notes: There can be double counting of manure exchanges, if, for example, manure is sold for cash and traded for grain.

In spite of the experimental evidence about response to mulch and to green manures, there were no field observations of intensive mulching techniques. For example, farmers in western Niger left crop residues to be grazed almost entirely; the remaining stalks were then piled up and burned just before planting time. Furthermore, there were no transactions in organic matter to be used as mulches; we observed no transactions in crop residues for soil restitution, and many transactions in crop residues for feed. This pattern of transactions demonstrates that farmers find it more profitable to graze crop residues and to leave any residual as mulch.

A GENERAL PERSPECTIVE

The comparative economics of manure and fertilizers depend on two questions: the consequences of different fertility techniques for long-run growth, and the presence of a specific effect in manure. The former is a long-run evolutionary problem; the latter is a short-run choice-of-technique problem.

The long-run problem is the contribution of different fertility techniques to agricultural growth in SSA. It has been shown that large additional quantities of manure are necessary to stabilize crop production in several environments. Those quantities are not readily available and, even if they were, do not allow growth, but only allow maintenance of yields at base levels. It is also true that manure supply, as a form of recycling, depends on biomass production in the system and, unlike fertilizers, is not an exogenous input. Therefore, manuring cannot be a strategy for overall agricultural growth and is not comparable to fertilizer in that sense.[5]

It is vital to understand that the insufficiency of manure cannot simply be remedied by integrating animal and crop production. This can be shown by studying the determinants of manure supply, and of the efficiency with which it is used.

First, total manure supply is a function of the stocking rate, which is itself a function of local comparative advantage in crop and animal production. For any comparative advantage, at some point, there is a conflict between land for animals and for crops. At that point, further increases in manure supply for crop production compromise land use for crop production. Because manure supply depends primarily on stocking rate, changes in ownership or management of animals without an increase in their numbers -- i.e., crop-livestock integration -- are not of primary importance in determining manure supply.

Second, technical efficiency in manure use is a function of land use intensity. The field visits confirmed what should have been known for a long time -- intensive techniques are not adopted in low population density sites. Outside the East African highlands, there were no examples of composting, manure improvement, or manure storage. While failure to use intensive techniques wastes nutrients, it is economically rational because the value of those nutrients is less than the labor necessary to use them.

Even if animals are poorly integrated into crop production -- animal traction is not general, manure production is technically inefficient -- not all manure is wasted. Field visits showed that manure is often used, that contracts exist to move it from animals to crops, that it is often allocated to responsive, high-value cash crops, and that it is sometimes traded in markets as a cash good. The evidence that manure is valuable proves that its use is not constrained by demand -- that is, by farmers' indifference to its utility -- but by supply, both of the material itself and of the resources, especially labor, necessary to use it.

Experimental evidence on the specific effects of organic matter is not definitive, probably because of complex interactions between the control fertility of many trials and added fertility. What does seem clear is that the specific effect is not very big. Without a specific effect, manure's short-run effects are due only to its nutrients, and are thus directly comparable to fertilizer's effects. The choice between manures and fertilizers is then one of lower input cost for a given output.

Because of different transport and application costs, the choice between manures and fertilizers will almost always be resolved in favor of the latter. However, the physical unavailability of fertilizers in many countries has severely biased both decisions made by farmers, and those made by the research and extension establishments, in favor of manures.

Experiments do show that there are major gains in manure DM quantity and nutrient quality by storage. However, introduction of better storage is severely constrained by labor, especially for transport. This constraint is much less severe for concentrated chemical fertilizers. Efforts to

---

[5] Exceptions are site-specific, for example, rapid development of market gardening based on intensive manure use.

relieve this constraint, as a means of improving manure use, have been hampered by the historical bias in traction research in favor of primary tillage and against transport.

REFERENCES

Allan, A.Y. 1971. Fertilizer use on maize in Kenya. In *Improving Soil Fertility in Africa.* FAO Soils Bulletin #14. FAO, Rome.

Bono, M., and L. Marchais. 1966. Le point des recherches rizicoles au Mali. *Agronomie Tropicale* 21:520-557.

Chabalier, P.-F. 1985. Bilans de fumures sous culture de maïs dans le centre de la Cote d'Ivoire. *Agronomie Tropicale* 40(3):253-260.

_______. 1986. Evolution de la fertilité d'un sol ferralitique sous culture continue de maïs en zone forestiere tropicale. *Agronomie Tropicale* 41(3-4):179-191.

Charreau, C., and R. Nicou. 1971. L'amélioration du profil cultural dans les sols sableux and sablo-argileux de la zone tropicale seche Ouest Africaine et ses incidences agronomiques. *Agronomie Tropicale* 26(2):209-255, (5):565-631, (9):903-978, (11):1184-1247.

Christenson, P. 1981. Rock phosphate fertilizer in Upper Volta: A report on policy implications of cereal yield response characteristics. SAFGRAD, Ouagadougou.

Couston, J.W. 1971. Summary of economic returns to fertilizer in African countries. In *Improving Soil Fertility in Africa.* FAO Soils Bulletin #14. FAO, Rome.

Doyle, J.J. 1971. Response of crops to fertilizer in Botswana, Lesotho, and Swaziland. In *Improving Soil Fertility in Africa.* FAO Soils Bulletin #14. FAO, Rome.

FAO. 1971. *Improving Soil Fertility in Africa.* FAO Soils Bulletin #14. FAO, Rome.

Ganry, F., and J. Bideau. 1974. Action de la fertilisation azotée et de l'amendement organique sur le rendement et la valeur nutritionelle d'un mil Souna III. *Agronomie Tropicale* 29(10):1015-1016.

Goldsworthy, P.R. 1967a. Responses of cereals to fertilizers in northern Nigeria. I. Sorghum. *Experimental Agriculture* 3(1):29-40.

_______. 1967b. Responses of cereals to fertilizers in northern Nigeria. II. Maize. *Experimental Agriculture* 3(3):263-274.

Hamon, H. 1972. L'habitat des animaux et la production d'un fumier de qualité en zone tropicale seche: Bilan de trois années d'étude. *Agronomie Tropicale* 27(5):592-607.

Heathcote, R.G. 1970. Soil fertility under continuous cultivation in northern Nigeria: I. The role of organic manures. *Experimental Agriculture* 6:229-237.

Jones, M.J. 1971. The maintenance of soil organic matter under continuous cultivation at Samaru, Nigeria. *Journal of Agricultural Science* 81(3):483-492.

_______. 1974. Effects of previous crop on yield and nitrogen response of maize at Samaru, Nigeria. *Experimental Agriculture* 10:273-279.

_______. 1976. The significance of crop residues to the maintenance of fertility under continuous cultivation at Samaru, Nigeria. *Journal of Agricultural Science* 86(1):117-125.

Kwakye, P.K. 1980. The effects of method of dung storage and its nutrient (NPK) content and crop yield in the northeast savanna zone of Ghana. In *Organic Recycling in Africa*. FAO Soils Bulletin #43. FAO, Rome.

Lal, R., and D.J. Greenland. 1979. *Soil Physical Properties and Crop Production in the Tropics*. New York: John Wiley and Sons.

Matlon, P.J. 1984. *Highlights of 1983 Annual Report, ICRISAT Economics Program in Burkina Faso*. ICRISAT, Ouagadougou.

McIntire, J. 1983c. *Annual Report of the ICRISAT Economics Program in Niger for 1982*. ICRISAT, Niamey.

_______. 1986. Constraints to fertilizer use in Sub-Saharan Africa. In *Management of Nitrogen and Phosphorus Fertilizers in Sub-Saharan Africa*, edited by A.O. Mokwunye, and P.L.G. Vlek, 33-58. Martinus Nijhoff, Dordrecht.

McWalter, A.R., and R.H. Wimble. 1976. A long-term rotational and manure trial in Uganda. *Experimental Agriculture* 12(3):305-317.

Mokwunye, A.O. 1980. Interaction between farmyard manure and NPK fertilizers in Savanna Soils In *Organic Recycling in Africa*. FAO Soils Bulletin #43. FAO, Rome.

Ofori, C.S. 1973. Decline in fertility status of a tropical forest ochrosol under continuous cropping. *Experimental Agriculture* 9:15-22.

Okalo, A.J., and K. Zschernitz. 1971. The FAO fertilizer programme in Kenya. In *Improving Soil Fertility in Africa*. FAO Soils Bulletin #14. FAO, Rome.

Okigbo, B.N., B.T. Kang, R. Lal, and F.E. Caveness. 1980. Studies on potential uses of crop residues and some industrial by-products in soil management in the humid tropics. *AAASA/ILCA Workshop on Appropriate Technologies for the Development of Agriculture in Africa. Addis Ababa, Ethiopia.*

Padwick, G.W. 1983. The maintenance of soil fertility in tropical Africa: A review. *Experimental Agriculture* 19:293-310.

Pichot, J., S. Burdin, J. Charoy, and J. Nabos. 1974. L'enfouissement des pailles de mil Pennisetum dans les sols sableux dunaires. *Agronomie Tropicale* 29(10):995-1005.

Pichot, J., M.P. Sedogo, J.-F. Poulain, and J. Arrivets. 1981. Evolution de la fertilité d'un sol ferrugineux tropical sous influence de fumures minerales et organiques. *Agronomie Tropicale* 37(2):122-133.

Pieri, C. 1973. La fumure des cereales de culture seche en République du Mali: Premier essai de synthèse. *Agronomie Tropicale* 28:751-766.

_______. 1985. Food crop fertilization and soil fertility: The IRAT experience. In *Appropriate Technologies for Farmers in Semiarid West Africa*, edited by H.W. Ohm and J.G. Nagy. Purdue University, West Lafayette, Indiana.

Poulain, J.-F., A. Doumbia, M. Franc, F. Jenny, C. Pieri, F. Thibout, and M.-F. Traore. 1976. Amélioration de la fertilité des sols agricoles au Mali: Bilan de treize années de travaux. *Agronomie Tropicale* 31(4):403-416.

Richards, I.R. 1979. Response of tropical crops to fertilizer under farmers' conditions--analysis of results of the FAO Fertilizer Programme. *Phosphorus in Agriculture* 76:147-156.

Stephens, D. 1969. Changes in yields and fertilizer responses with continuous cropping in Uganda. *Experimental Agriculture* 5:263-269.

Traore, M.-F. 1974. Etude de la fumure minerale azotée intensive des céréales et du role specifique de la matière organique dans la fertilité des sols du Mali. *Agronomie Tropicale* 29:567-586.

Thibout, F., M.-F. Traore, C. Pieri, and J. Pichot. 1980. L'utilisation agricole des phosphates naturels de Tilemsi (Mali): Synthèse de résultats de la recherche agronomique sur les cultures vivrières et oléagineuses. *Agronomie Tropicale* 35(3):240-249.

van Raay, J.G.T., and P.N. de Leeuw. 1971. *The Importance of Crop Residues as Fodder: A Resource Analysis in Katsina Province, Nigeria.* Samaru Research Bulletin #139. Institute of Agricultural Research, Zaria, Nigeria.

IMPORTANCE OF ANIMAL AGRICULTURE IN ASIAN PRODUCTION SYSTEMS

B. Gunawan
Balai Penelitian Ternak
P.O. Box 123, Bogor, Indonesia

INTRODUCTION

In developing countries, 37% of all meat is produced by ruminants. Twenty-eight percent comes from bovines and 9% from sheep and goats. On the other hand, 70% of the world cattle and buffalo populations are in the developing countries, but reproductive performance and productivity of these animals are low. To meet the increasing demand for meat protein in the developing countries, total meat productivity, a function of animal growth rate and reproductive performance, must be increased.

This paper aims to review the status of animal production in Asia, with particular reference to Indonesia, and to delineate some of the constraints and prospects for development to the year 2000.

PRESENT STATUS OF ANIMAL PRODUCTION

Livestock numbers since 1969-1971 in Southeast Asia and the South Pacific are in Table 1. Large ruminants are concentrated in Burma, Thailand, and Indonesia while Indonesia accounts for more than three quarters of the small ruminants in the region.

The trends in ruminant populations in Southeast Asia and the South Pacific have been discussed by Remenyi and McWilliam (1985) and will not be discussed further here.

In Southeast Asia and the South Pacific, increased income tends to result in proportionate increases in demand for meat. Assuming the income trends since the 1960s are sustained, the demand for and production of meat by 1990 and year 2000 are compared in Table 2.

The values show the importance of dramatically increasing meat production in order to better meet the rapidly growing demand.

A decline in livestock population, especially ruminant, occurred in Indonesia but has now been overcome. Development in the animal husbandry sector achieved successful results and the livestock population is showing a trend of increase (Table 3). The demand for meat, eggs, and milk has steadily increased in response to growth in human population and per capita income. Nevertheless, the supply within the country is not sufficient and imports of meat, eggs, and milk cannot be avoided.

Table 4 shows that the animal protein consumption is equivalent to 2.55 grams/capita/day which is far below the targeted minimal requirement of about 4 grams which corresponds to consumption of 6 kg of meat, 4 of eggs, and 4 of milk per capita per year.

Table 1. Ruminant numbers in Southeast Asia and the Pacific (000 head)

	Large ruminants						Small ruminants					
	Cattle			Buffalo			Sheep			Goats		
Years	69-71	74-76	1983	69-71	74-76	1983	69-71	74-76	1983	69-71	74-76	1983
ASEAN	12,860	12,593	13,746	13,596	11,160	11,913	3,314	3,392	4,418	8,138	8,970	10,144
Brunei	2	3	4	16	14	15	na	na	na	1	1	2
Indonesia	6,338	6,239	6,600	3,180	2,424	2,500	3,207	3,267	4,300	6,941	7,252	1,900
Malaysia	314	425	600	303	286	300	38	46	66	362	352	350
Philippines	1,701	1,716	1,938	4,452	2,723	2,946	28	30	30	798	1,333	1,859
Singapore	8	5	4	3	2	2	na	na	na	2	2	3
Thailand	4,470	4,205	4,600	5,642	5,711	6,150	41	49	22	34	30	30
Other SE Asia	11,350	10,409	13,038	5,671	5,150	5,918	190	200	279	790	761	1,029
Burma	6,949	7,410	9,400	1,593	1,710	2,150	177	187	260	573	579	770
Kampuchea	2,233	1,150	1,148	903	593	468	2	2	1	1	1	1
Laos	418	326	490	932	621	910	na	na	na	34	31	58
Vietnam	1,750	1,523	2,000	2,333	2,226	2,390	11	11	18	182	190	200
South Pacific	492	571	571	na	na	na	4	5	4	101	89	87
Fiji	149	158	157	na	na	na	na	na	na	65	56	55
N. Caledonia	120	113	100	na	na	na	4	5	2	14	11	8
PNG	79	126	134	na	na	na	na	na	2	16	15	16
Samoa	22	22	26	na	na	na	na	na	na	na	na	na
Solomon Is.	12	23	23	na	na	na	na	na	na	na	na	na
Vanuatu	77	105	100	na	na	na	na	na	na	6	7	8
Other	33	24	31	na	na	na	na	na	na	na	na	na

Source: FAO, Production Yearbook, various years.

CONSTRAINTS

In contrast to the developed countries, most animals in developing countries are kept in traditional ways. Each farmer has only 1 to 10 animals that are mainly fed low quality feeds such as roadside grasses. This is primarily because the farmers need animals mainly for cash income, savings, or as a hobby, and have little animal husbandry due to lack of education and commitment. Less than 20% of the animals are raised for commercial purposes. Farmers have very little capital which makes it difficult to buy feed concentrates.

Livestock generally use only 5% of farm capital and contribute relatively little to gross farm income (Sabrani *et al.*, 1982). The average farm size is about 0.6 ha in Java and 1.5 ha in the outer islands, averaging 0.98 ha for all of Indonesia, and continues to decline with time (Hill, 1971; de Vries, 1972). Even worse, livestock owners are not always landowners. Basuno (1983) found that in a village in West Java up to 40% of livestock owners were landless.

Table 2. **Projected meat consumption and production trends in East and Southeast Asia (000,000 t)***

	Actual**		Projected	
	1961-1965	1973-1977	1990	2000
Meat consumption	2.2	3.4	7.3	12.8
Meat production	2.1	3.2	5.4	7.9
Balance	-0.1	-0.2	-1.9	-4.9

* Includes ASEAN, Burma, Fiji, Hongkong, Kampuchea, N. and S. Korea, Laos, Mongolia, PNG, and Vietnam.
** Ruminant meat represented 55% in 1961-65 and 51% in 1973-77.

Source: Sarma and Yeung, 1975.

Table 3. **Poultry and livestock population from 1978-1984 in Indonesia (000 head)**

Commodity	1978	1980	1982	1984
Dairy cattle	93	103	140	173
Beef cattle	6,330	6,440	6,594	6,741
Buffalo	2,312	2,457	2,513	2,724
Goat	8,051	7,691	7,891	8,210
Sheep	3,611	4,124	4,231	4,402
Pig	2,902	3,155	3,587	3,854
Horse	615	616	658	672
Native chicken	108,916	126,316	139,787	157,064
Layer	6,071	22,940	26,312	31,947
Broiler	0	25,462	31,033	37,548
Duck	17,541	21,078	23,861	27,144

With the constraints mentioned, should farmers totally switch to intensive animal production to meet the demand for meat, eggs, and milk consumption? If this system is going to be adopted, are we ready with the high-input, high-cost technology that continuously supplies improved breeds, concentrates, and vaccines? Even though this is working in the poultry industry, during certain times of the year poultry farmers complain of the very expensive imported ingredients used in

Table 4. Production, imports, and meat consumption

Commodity	1978	1980	1982	1984
Meat (000 t)				
Domestic production	474.6	570.8	628.6	685.6
Imports	1.7	1.6	2.6	2.2
Eggs (000 t)				
Domestic production	122.7	207.7	242.9	282.4
Imports	0	0.1	0.2	1.5
Milk (000 t)				
Domestic production	54.2	68.6	102.1	462.3
Imports	440.3	594.3	536.0	622.8
Consumption (kg/capita/year)				
Meat	3.4	3.9	4.1	4.3
Eggs	0.9	1.4	1.6	1.8
Milk	4.2	4.4	4.2	3.9

concentrates such as maize, soybean meal, and fish meal. Prices of poultry products such as broiler meats and eggs also fluctuated during the year making the business unattractive to farmers.

With other commodities such as dairy cattle, the predicament is even worse. Milk production of improved imported breeds (usually Holstein-Fresian) vary from 8 to 40 liters/day with an average of about 10 liters/day. With a very high input cost for feeds, this is not going to be an attractive option. The question also arises as to the source of imported cattle; should they be from the U.S.A., Australia, or New Zealand? The most practical judgement criteria is what will bring the farmer the highest profit. High production, although important to the country, is not the only factor that is important to the farmer who must consider input cost needed to pay for that production. To meet the demand for milk consumption, the industry tends to purchase any available dairy cattle breed. They pay more attention to how many cattle can be purchased immediately than to the quality of the breed itself. They tend to think of short-term improvement rather than long-term solution, and how they can increase milk production by importing more cattle. For long-range improvement in animal production, this policy is absolutely wrong. We already have evidence that many cattle business companies are becoming bankrupt because they purchased the wrong cattle.

Should we also import sheep, goats, and other commodities from overseas? This is a typical problem for most of the Asian countries which tend to have a low appreciation of their own native breeds. The general assumption is that exotic breeds are better. As a consequence, indiscriminate crossing and the associated risk of losing some of the high genetic potential of local breeds cannot be avoided. In fact a lot of evidence indicates that the exotic is not always better than the local breeds. For example, a study by Gunawan and Bakrie (1987) showed that even though the local Javanese Thin Tail (JTT) breed grows more slowly than the imported Suffolk (S), Wiltshire Horn (WH), and Polled Dorset (PD), total productivity of JTT is higher than crosses of these breeds with the native JTT. More importantly, the local JTT eat less feed, thus improving the output/input ratio (Table 5). We also have evidence that the performance of the JTT breed can be improved by better management systems and better nutrition (Table 6). Importation of temperate breeds of sheep is not recommended (Gunawan and Bakrie, 1987). Other imported species should be properly evaluated under Indonesian conditions before they are distributed throughout the country.

What, then, is the best strategy for improving animal production and increasing the income of the farmer?

Table 5. Reproductive performance of JTT and their crosses with Suffolk (S), Polled Dorset (PD), and Wiltshire Horn Rams (WH) to 2 years of age

		Crossbreds			
	JTT/JTT	S/JTT	PD/JTT	WH/JTT	Std. Dev.
No. ewes joined	14	16	17	9	
Mean age at 1st lambing (day)[1]	348^{a}	432^{b}	456^{b}	427	67.56
No. lambs born	48	34	16	18	
No. lambs weaned	33	31	7	14	
Fertility (EL/EP)	0.87^{c}	0.65^{b}	0.43^{a}	0.37^{a}	0.45
Prolificacy (LB/EL)	1.41^{a}	1.41^{a}	1.33^{a}	1.64^{a}	0.75
Ewes survival (EP/EJ)[2]	0.93^{a}	0.94^{a}	1.00^{a}	1.00^{a}	0.19
Lambs survival[3]					
singles	1.00^{b}	0.89^{a,b}	0.64^{a}	1.00^{b}	0.33
multiples	0.63^{b}	0.92^{c}	0.00^{a}	0.73^{b,c}	
Productivity (LW/EJ)	2.36^{c}	1.94^{b}	0.41^{a}	1.56^{b}	0.49
Total productivity (TWLW/EJ) (kg)	32.57^{b,c}	35.67^{c}	10.12^{a}	26.22^{b}	10.37

EP = number ewes present at lambing, EL = number ewes lambing, LB = number lambs born, LW = number lambs weaned, TWLW = total live weight of lambs weaned.

[1] Means followed by same superscript are not significantly different (P>0.005).
[2] Ewes survival to 2 years of age.
[3] Lambs survival to weaning (13 weeks).

Source: Gunawan and Bakrie (1987).

Table 6. Performance of sheep and goats in Java under village and "improved" conditions

	Village		Improved	
	Sheep	Goats	Sheep	Goats
Fertility (%)	87	91	98	96
Offspring born (% of ewes joined/year)	148	152	309	368
Parturitions/year	1.25	1.50	1.84	1.85
Mortality (%):				
Birth - 3 months	46	45	32	41
Dams/year	16	17	14	8
Offspring weaned (% per year/ewe joined)	79	85	210	215
Growth rate (grams/day)	< 50	< 50	150	150

Adapted from Obst (1980) and Chaniago *et al.* (1984).

STRATEGY FOR ANIMAL AGRICULTURE IMPROVEMENT

To increase animal production, especially that of ruminants, the continuity of forage supply is becoming a critical problem. There is 1% of nonirrigated farm land available for forage production (0.4% in Java and 1.2% in the other islands) (Table 7). The dryland areas of Indonesia are unable to support the existing livestock population using improved forages, and their feed must be supplemented from other sources such as agricultural by-products. The important agricultural by-products having potential use in the diets of ruminants and their distribution and utilization in the three regions of Java are in Table 7. Data on crop area and production, calculated grain yield and amount of fibrous residues for the years 1978-82 are in Table 8. These residues are expressed as a percentage of the respective primary product in Table 9, together with values for dry matter digestibility measure *in vitro*. The latter can be used to estimate annual fibrous residue yield of digestible dry matter.

It has been estimated that the major fibrous residues available would theoretically support about 33% more ruminants (expressed as one livestock unit (LU) of about 250 kg) than at present. This estimate does not include many agricultural feed residues, such as cassava waste and less conventional waste products (Jan Nari, 1985). At present only small quantities of these residues are used for feeding livestock (Table 7). Some quantities are returned to the soil to maintain fertility; some are wasted or burned. The utilization of agricultural by-products could clearly be increased somewhat in balance with the need to maintain stability. A significant amount of research has been directed toward the utilization of local feedstuffs and by-products, along with efforts to overcome their nutritional limitations. Examples are rice bran, rice straw, sugarcane tops,

Table 7. Production (000,000 t) and utilization (%) of agricultural crop residues in regions of Java and Indonesia

	W. Java		C. Java		E. Java		Indonesia
	P	U	P	U	P	U	P
Rice straw	12.8	4	10.6	24	11.6	43	72.5
Corn stover	0.2	80	1.1	68	2.2	79	5.3
Cassava leaf	0.6	56	1.0	63	1.2	50	-
Sweet potato straw	0.2	79	0.1	33	0.2	50	0.6
Peanut vines	0.1	69	0.2	89	0.1	93	0.6
Soybean straw	0.03	25	0.2	13	0.5	67	1.0
Sugarcane tops	-	-	4.4[a]	70	-	-	5.0

P = production, U = utilization.

[a] All Java.

Source: Rabarjo *et al.* (1981).

coconut meal, and other crop residues and tree legumes (*Leucaena*, *Sesbania*, *Albizzia*, etc.). Rice bran is a major by-product of milling of rice which is produced in large quantities in Indonesia.

In sheep, utilization of rice bran, cassava leaves, and elephant grass increased growth rates to 50 to 70 grams/day, compared to 30 grams/day when using only village feedstuffs. Chemical and physical pretreatment of rice straw such as alkali treatment, chopping, or steaming could increase its acceptability and digestibility. Supplementation of rice straw diets with cassava leaves increased growth rates to about 100 grams/day. Rice straw treated with urine increased intake by up to 40%. Wilted *Gliricidia* leaves fed *ad libitum* increased growth rates to 90 to 110 grams/day. Growth rates increased to 65 grams/day with a supplement of dry *Leucaena* compared with about 170 grams/day on high-quality rations. Bean curd waste is a good diet for sheep and increased growth rates between 90 and 1,509 grams/day. It has been widely used by farmers in West Java. The use of agricultural by-products in ruminant diets is not going to be further discussed as it has been reviewed by Ffoulkes (1985). Use of legumes in increasing animal production has been discussed by Gunawan and Manrung (1987). However, a major constraint to the utilization of fibrous feed residues for animal production is that in developing and implementing appropriate technology at the village level, social and economic considerations that are often as important as the technology itself are often ignored.

Given the small average farm size, what would be the optimal strategy to be used for lands with this limitation to produce food crops sufficient to meet family requirements? The objective should be to make more efficient use of arable land to further increase the farm income. Since the Government of Indonesia's targeted income for farmers is about US $1,500/family/year, other agricultural enterprises must be added to the farming system to meet this goal, for example, the

Table 8. Area harvested, production, product yield, and food crop residues for Indonesia

	1978	1979	1980	1981	1982
PADDY[a]					
Area (000 ha)	8,929	8,804	9,005	9,382	8,988
Production (000 t)	25,712	26,283	29,652	32,774	33,583
Yield (t/ha)	2.89	2.99	3.29	3.49	3.74
Straw (000 t)[b]	55,667	56,771	64,048	70,792	72,541
MAIZE					
Area (000 ha)	3,025	2,594	2,735	1,955	2,061
Production (000 t)	4,029	3,606	3,993	4,509	3,234
Yield (t/ha)	1.33	1.39	1.46	1.53	1.57
Stover (000 t)[b]	6,608	5,913	6,550	7,395	5,305
SWEET POTATOES					
Area (000 ha)	301	287	276	275	220
Production (000 t)	2,029	2,194	2,078	2,094	1,676
Yield (t/ha)	6.90	7.60	7.50	7.60	7.60
Leaf (000 t)[b]	690	746	706	712	570
PEANUTS					
Area (000 ha)	506	473	506	508	461
Production (000 t)	446	424	470	475	437
Yield (t/ha)	0.88	0.90	0.93	0.93	0.95
Vines (000 t)[b]	497	569	630	636	585
SOYBEANS					
Area (000 ha)	733	784	732	810	608
Production (000 t)	617	680	653	704	521
Yield (t/ha)	0.84	0.87	0.89	0.87	0.86
Straw (000 t)[b]	1,215	1,339	1,286	1,387	1,027
SUGARCANE					
Area (000 ha)		165			287[c]
Production (000 t)		1,331			1,779
Yield (t/ha)		0.80			0.63
Tops (000 t)		3,277			5,700

[a] Dry unhusked rice.
[b] Calculated from Rabarjo *et al.* (1981). Statistik Indonesia (1983), Biro Pusat Statistik, Jakarta.
[c] Data for 1984.

Table 9. Fibrous waste expressed as a percentage of primary product, mean *in vitro* digestibility of dry matter of the waste, and calculated digestible dry matter yield

	Percentage of primary product[a]	Digestibility[b] (%)	DDM yield (000 tons)
Rice straw	216	29	21,036
Maize stover	164	47	2,493
Cassava leaves	31	-	-
Sweet potato leaves	34	60	342
Peanut vines	134	53	310
Soybean straw	197	53	545
Sugarcane tops	19	43	2,550
Total	-	-	27,276

DDM = digestible dry matter.

[a] Raharjo *et al.* (1981).
[b] Musofie (1984).

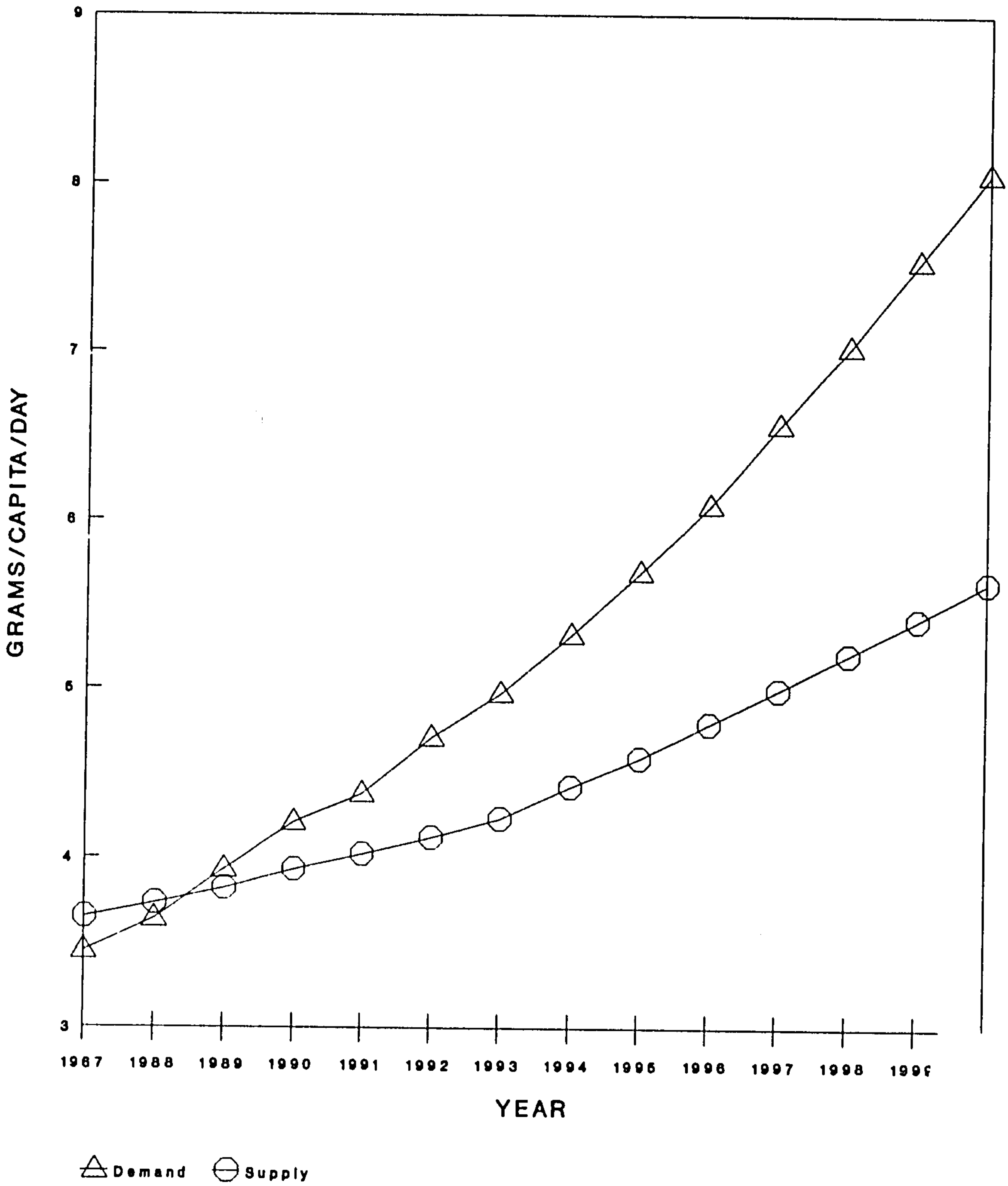
inclusion of perennial crops or livestock. Table 10 summarizes the results of a study conducted in an upland area with a humid climate located in transmigration area of Batumarta, South Sumatra, Indonesia. The results indicate that with the incorporation of a perennial crop (rubber) and livestock in the farming system, the total income obtained was about three times greater than that from existing farm systems without livestock. The income obtained from the introduced model (Rp 1.5-1.6 million) during the wet season 1986/87 was about 62% of the US $1,500/family/year target. It is predicted that the targeted income can be reached in the third year. For a more detailed explanation see Ismail *et al.* (1987).

Assuming success in increasing animal production, the combined supply and demand for meat, eggs, and milk toward the year 2000 in Indonesia are presented in Figure 1. The projection is based on an optimistic 5% economic growth and 2.02% population growth per year. Income elasticity is assumed to be 1.30, 1.20, and 1.0 for meat, eggs, and milk, respectively. Based on this projection, the government target for minimum protein requirement of about 4 grams/capita/day will be achieved in the year 1989. Calculations are based on the assumption that the price of animal protein can be reduced from the 1988 level of 2.24% to 3.46% per year and that the elasticity range is from -1 to -0.65. This is the prime challenge for research scientists: to provide appropriate technology with which farmers can increase their incomes.

Table 10. Summary of performance of each farming systems model tested in Batumarta, South Sumatra, Indonesia

	Farming systems model			
	A	B	C	D
Production cost (Rp 000)				
Food crops	281.0 (66%)	345.5 (78%)	514.8 (63%)	620.0 (59%)
Rubber	144.6 (34%)	-	141.9 (17%)	176.3 (17%)
Livestock	-	95.8 (22%)	164.5 (20%)	257.1 (24%)
Total	425.6	441.0	821.2	1,053.4
Production value (Rp 000)				
Food crops	440.2 (48%)	689.6 (78%)	1,103.0 (45%)	1,029.8 (40%)
Rubber	481.6 (52%)	-	706.8 (29%)	831.8 (32%)
Livestock	-	189.6 (22%)	655.0 (26%)	724.9 (28%)
Total	921.8	879.2	2,464.8	2,586.5
Net value (Rp 000)				
Food crops	225.1 (40%)	344.4 (78%)	588.2 (36%)	409.8 (27%)
Rubber	337.1 (60%)	-	564.9 (34%)	655.5 (43%)
Livestock	-	93.8 (22%)	490.5 (30%)	467.8 (30%)
Total	562.2	438.2	1,643.6	1,533.1
Labor use				
Man-days	233.1	200.2	347.5	372.2
Animal-days	9.6	10.6	25.3	41.8

Figure 1. Supply and demand of animal protein



REFERENCES

Basuno, E. 1983. Small-scale animal husbandry at the village level: A case study in Desa Pandasari, Kecamatan Ciawi, Bogor, West Java. M. Phil. Thesis, Griffith University, Brisbane, Australia.

Buku Statistik Peternakan. 1983 Direktorat Bina Program. Direktorat Jendral Peternakan.

Chaniago, T., J.M. Obst, A. Parakkasi, and M. Winugroho. 1984. Growth of Indonesian sheep under village and improved management systems. *Proceedings pertemuan ilmiah penelitian ruminansia kecil, Bogor, Indonesia*. Pusat Penelitian dan Pengembangan Peternakan.

De Vries, E. 1972. *Masalah-masalah petani Jawa*. Bharat Jakarta.

FAO. Various years. *Production Yearbooks*. Rome.

Ffoulkes, D. 1985. Practical feeding systems for ruminants based on sugar cane and its by- products. In *Ruminant Feeding Systems Utilizing Fibrous Agricultural Residues*, edited by R.M. Dixon, 11-26. Canberra, Australia.

Gunawan, B., and B. Bakrie. 1987. Evaluation on the reproductive performance of Javanese Thin Tail sheep and their crosses with Suffolk, Wiltshire Horn and Polled Dorset rams. *Majalah Ilmu dan Perternakan* 3(2):47-49.

Gunawan, B., and T. Manurung. 1987. The role of legumes in increasing animal production. *Symposium on the contribution of biological nitrogen fixation to plant production, Cisarua, Indonesia, August 3-7, 1987.*

Hill, T.M. 1973. *A Study of Ruminant Animal Production Potential to Alleviate Protein Deficiencies of Human Diets in Java and Madura*. Department of Animal Science, University of Illinois.

Ismail, I.G., U. Kusnadi, and H. L.Supriadi. 1987. *Crop-Livestock Systems Research*. Annual Report for 1986/1987. Agency for Agricultural Research and Development, Indonesia.

Musofie, A. 1984. Pengaruh proses pelleting terhadap kecernaan dan konsumsi pucuk tebu. Thesis MS, Fakultan Peternakan, Universitas Gajah Mada.

Nari, Jan. 1985. Fibrous feed residues and their potential in livestock feeding systems in Indonesia. In *Ruminant Feeding Systems Utilizing Fibrous Agricultural Residues*, edited by R.M. Dixon, 3-10. Canberra, Australia.

Obst, J. 1980. An approach to animal production research in Indonesia. Paper presented at a seminar at Research Institute for Animal Production, Ciawi, Indonesia.

Petheram, R.J., A. Thahar, and R.H. Bernsten. 1985. Socioeconomic aspects of draught animal power in Southeast Asia, with special reference to Java. In *Draught Animal Power for Production*, edited by J.W. Copland. Proceedings of an international workshop held at James Cook University, Townsville, Qld., Australia, July 10-16, 1985.

Raharjo, A., P. Sulistioningsih, H. Priyanto, C. Gunawan, and IG. Suharto. 1981. *Proceedings of First Asian Workshop on the Technology of Animal Feed Production Utilizing Food Waste Material held at Bandung, Indonesia*, edited by Oei Ban Liang and A.T. Karossi.

Remenyi, J.V., and J.R. McWilliam. 1985. Ruminant production trend in Southeast Asia and the South Pacific, and the need for forages. In *Forages in Southeast Asia and South Pacific Agriculture*, edited by G.J. Blair, D.A. Ivory, and T.R. Evans. Proceedings of an international workshop held at Cisarua, Indonesia, August 19-23, 1985.

Sabrani, M., A. Mulyadi, and A.J. De Boer. 1982. Small ruminant production on small farms in West Java, Indonesia: Preliminary results of a baseline survey of upland and lowland farming systems. Paper presented at the Third International Conference on Goat Production and Disease, Arizona, U.S.A., January 10-15, 1982.

Sarma, J.S., and P. Yeung. 1975. *Livestock Products in the Third World: Past Trends and Projections to 1990 and 2000.* IFPRI Research Report 49. International Food Policy Research Institute, Washington, DC, April, 1975.

THE CONTRIBUTION OF ANIMAL AGRICULTURE TO ECONOMIC WELFARE IN DEVELOPING COUNTRIES

Lovell S. Jarvis
Department of Agricultural Economics
University of California, Davis

INTRODUCTION

This paper discusses the multiple ways in which livestock contribute to national welfare in developing countries and, by examining how the use of livestock varies in response to changing supply and demand factors, suggests some fundamental elements of livestock development strategies.

Livestock are a more important national resource in most developing countries than is generally realized. On average, livestock account for fully half of agricultural output when both their direct and also their indirect contributions are considered. Directly, livestock provide food and nonfood products amounting to about 20% of agricultural Gross Domestic Product (GDP). Indirectly they contribute another 30% by supplying inputs vital to agricultural production.

Livestock provide important food products, principally meat, milk, and eggs. These products contain energy and high-quality protein in very palatable form and are desirable components of the diet in nearly every country. Simultaneously, livestock benefit farmers by generating productive employment and income. Livestock play an especially key role in the lives of many smallholders and have potential for further contributions to alleviate poverty. Livestock are important investments which offer a competitive return on relatively small amounts of capital and are easily marketed when cash is needed. Livestock convert crop residues, agricultural by-products, and pastures on marginal lands, all feeds which have limited alternative uses into a range of higher value products for subsistence and sale. Simultaneously, the integration of livestock into cropping, via draft power and manure, increases the area cultivated, improves the timeliness of agricultural operations, and helps to maintain soil structure and fertility. Livestock sales and slaughter provide many countries with important tax revenues and livestock exports yield foreign exchange. Livestock products are utilized as raw materials in many industries in which additional employment and value-added are created. Finally, the livestock industry stimulates activity in other sectors by demanding their products, e.g., feedgrains purchased from the agricultural sector.

Because livestock food products command high prices, they are usually consumed in greater amount by individuals having higher rather than lower incomes (although livestock products absorb a high proportion of the expenditures of poor households in some countries, especially in parts of Latin America and Africa, e.g., Muchnik de Rubenstein and Nores (1980), Jarvis (1986)). However, even where the poor consume few livestock products, it is economically attractive for many poor rural households to produce livestock products and exchange these, via the market, for other foods which provide cheaper sources of energy and protein.

Livestock vary substantially by species and breed in their capacity to produce different types of outputs and to utilize different types of inputs. There are two broad subclasses of livestock, viz., ruminants (large and small) and nonruminants (monogastrics). Cattle and buffalo typify large ruminants, and sheep and goats are examples of small ruminants. Environmental conditions, the farming systems utilized, and consumer demand (income and cultural preferences) are crucial determinants of the animal species which should be targeted for use in particular circumstances (Jarvis, 1987).

Ruminants, e.g., buffalo, cattle, goats, and sheep, have the capacity to utilize low-quality, bulky feeds such as pasture, crop and industrial by-products having few alternative uses and to convert these feeds into higher value products. Large ruminants, e.g., buffalo and cattle, also provide draft power and are by far the main source of milk. Small ruminants, e.g., goats and sheep, are generally more prolific, produce wool and hair in addition to meat and milk, and can prosper under poorer range conditions than large ruminants (though sheep generally do poorly in tropical areas). Small ruminants are also a more convenient household source of meat, barter, and cash, though they are also more easily stolen. In many situations, large and small ruminants are complementary in production because they utilize different forage species. Diversification of disease risks is further reason for running them jointly.

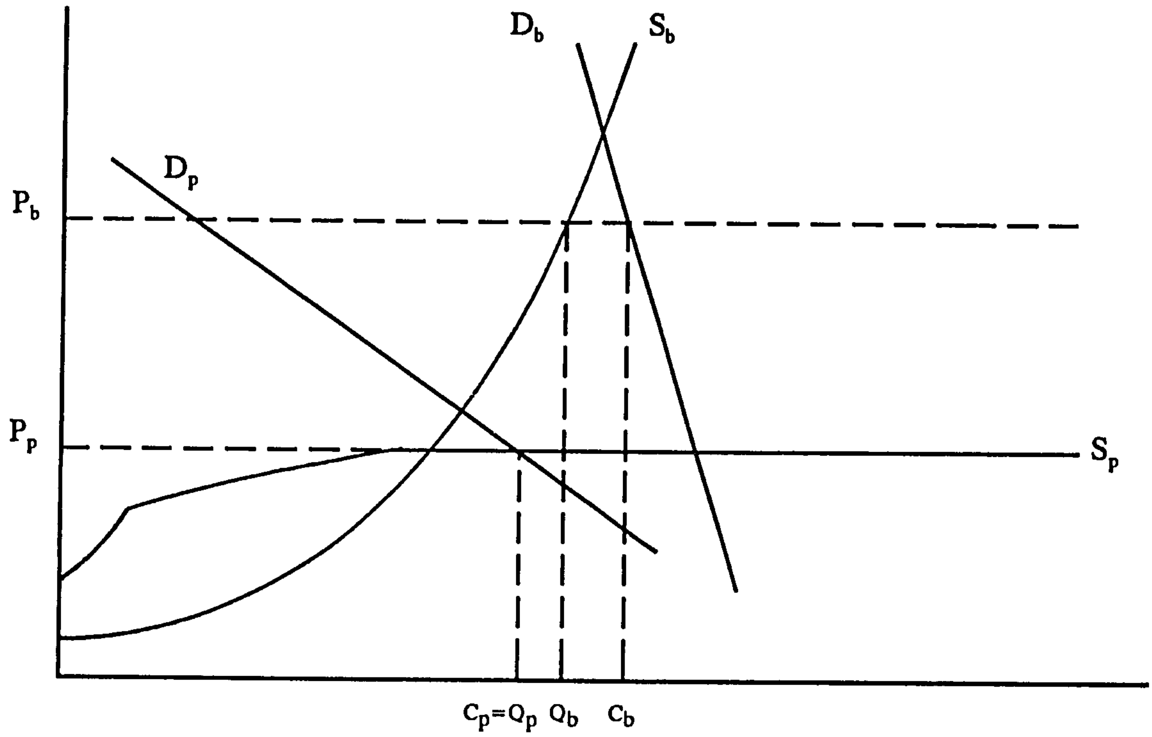
Nonruminant or monogastric livestock, e.g., poultry and swine, are utilized primarily for meat production, though swine also produce hides and poultry feathers and down, and both produce manure. The principal economic advantage of nonruminants is their ability to convert high-energy/protein feeds into meat at a more favorable ratio than can ruminants. Such feeds are expensive, being much in demand for direct human as well as for animal consumption.

Where pasture, forage or low-quality crop by-products are available (or can be economically increased), ruminants provide meat and milk at low cost. There is great potential to increase pasture production in Latin America and so increase beef and milk production (Seré and Jarvis, 1988). Similar potential probably exists in much of Africa if a solution to trypanosomiasis can be found. (Wool is produced from sheep, also on extensive range. The choice between whether range is used for sheep or for cattle depends importantly on the relative price of wool and beef.) In most other regions, pastures are limited in area and increased meat production probably will have to come mainly from swine and poultry fed on grains and high-quality agro-industrial by-products. Such production will commonly take place in large, industrial-type enterprises close to urban centers. Technical change in the poultry industry has led to rapid decline in the cost of poultry in most countries, resulting in rapid growth in poultry's share of meat consumption.

As noted, large ruminants, especially cattle, produce a wide variety of outputs, with pigs and poultry being used almost exclusively to produce meat, and they are fed different feeds. Thus, in most countries there are two distinct livestock strategies: 1) the feeding of inexpensive, low-quality pasture resources to ruminants for producing meat, milk, wool, manure, and draft power, and 2) the feeding of expensive, high energy, high-protein grains to nonruminants for producing meat. The second strategy is particularly important whenever the demand for meat exceeds the amount which can be produced from ruminants with the low-cost feed resources available. It is uneconomic to produce beef using feedgrains except where beef prices are unusually high, though the price of milk will more frequently justify this.

The situation described is depicted in Figure 1. The supply of beef is given by S_b. Relatively small amounts of beef are available at a low cost, but once the inexpensive forage and by-products become scarce the marginal cost of producing beef rises rapidly. Because beef has a higher marginal cost of production, international trade ensures that beef is the most expensive meat in most countries. In the case shown, the domestic demand, given by D_b, cuts S_b at a price above

Figure 1. Characteristic supply and demand curves for beef and poultry in less developed countries



the international price. If international trade in beef is permitted, domestic consumption, C_b, will be greater than domestic production, Q_b, with the difference being imported.

The supply of meat from poultry is given by S_p. Although small amounts of "backyard" poultry can be produced at low cost, poultry is produced primarily in large enterprises where feedgrains regularly account for 70% or more of the unit cost. Because feedgrains can be imported at an essentially constant price, the supply of poultry meat is relatively elastic.

The price elasticity of demand for beef is depicted as being lower than that of poultry, a situation which seems to hold in Mexico and an important number of other developing countries (Perali, 1988; Rivas *et al.*, 1987). More importantly, the income elasticity of demand for poultry also seems higher than that for beef when the relative prices of the two meats are roughly as shown and for intermediate income levels. These facts suggest that poultry production and consumption will probably expand more rapidly than that of beef in most developing countries.

Despite the expected rapid growth in demand for poultry, smallholders in developing countries can be expected to rely on ruminants as their primary livestock assets both because ruminants use more efficiently the low-quality feeds generated by the farm enterprise and also because ruminants provide a wider range of products, particularly draft and manure, which are crucial to their overall farming system. In meat production, smallholders can compete effectively with larger industrial-type enterprises only to the extent that smallholders have access to low-cost farm resources, especially feed and labor, which cannot economically be sold off-site. Such low-cost resources usually result from the integration of agricultural and livestock activities. Many smallholders will find it profitable to maintain a small number of other types of livestock to utilize that feed which ruminants do not convert well, to provide diversity to the family diet, and to provide assets which can be liquidated in more easily and in smaller amounts. However, the increasing amounts of inexpensive poultry and pork produced, processed and distributed in large integrated enterprises make it increasingly difficult for smallholders to profit from the sale of such livestock.

THEORETICAL CONSIDERATIONS ON THE USE OF LIVESTOCK AS CAPITAL GOODS

The most important livestock products in terms of value are meat, milk, traction, manure, fibres, hides, and skins, though animals also provide prestige and enjoyment and have served a monetary function in some areas. Breeding is also an economically important activity.

Using the simple principle that livestock are capital goods which can be combined with other resources such as pasture, agricultural by-products, feedgrains, labor, and other forms of capital to produce a variety of end-products (Jarvis, 1974, 1982b, 1986), it can be shown how supply and demand factors -- resource availability and the need for different products -- determines both the type and number of livestock used by producers and the mix of livestock products which is sought.

Many of the economic decisions taken by a producer regarding his livestock can be represented by equations of the following form which relate the profit earned by investing in an animal to the various outputs it produces and the costs of its maintenance. The equation given is for cattle:

$$(1)\quad \pi = pw\,e^{-r\theta} + vd\int_0^\theta e^{-rt}dt + nm\int_0^\theta e^{-rt}dt + lq\int_0^\theta e^{-rt}dt + \sum_{t=1}^{\theta}\frac{zb}{(1+r)^t} - ci\int_0^\theta e^{-rt}dt.$$

where:

π = the profit which will be realized on the animal by maintaining and using it from birth to some specific slaughter age, θ,

θ = the age of slaughter,

p = the unit price received for beef at the time of slaughter,

w = the carcass weight of the animal at slaughter,

r = the interest rate which the producer can earn on investments, i.e., the opportunity cost of the capital invested in livestock,

v = the value of draft services per period, i.e., per day used,

d = the amount of draft services performed by the animal in each period,

t = time,

n = the unit price received for milk,

m = the amount of milk produced in each period,

l = the unit value of manure,

q = the amount of manure produced in each period,

z = the value of a calf,

b = the number of calves produced in each period,

c = the unit cost of the package of inputs needed to maintain the animal, e.g., feed, shelter, labor, and veterinary supplies, and

i = the amount of inputs used to maintain the animal in each period.

The equation can be interpreted as follows: given an animal at birth, the goal of each producer should be to maximize the profitability of raising the animal. To do so, the producer must consider the genetic potential of the animal to produce desired products in response to the various inputs available, the potential costs of the inputs needed and the value of the outputs produced. The profitability of raising the animal is then an increasing function of the animal's ability to produce meat, draft services, milk, manure, and other animals (breeding), less the cost of inputs required to achieve such outputs, e.g., feed, labor and management, veterinary medicines, and shelter.

The interest rate plays an important role because the producer must earn a return on the capital initially invested in his livestock asset -- plus that capital subsequently incorporated in the form of inputs to maintain the animal -- at least sufficient to compensate him for what he could have earned by investing his capital elsewhere. If the present value of the sum of the outputs is not at least equal to the present value of the inputs needed for maintenance, the producer will choose not to invest in livestock, i.e., livestock will not be used. If the present value of outputs exceeds that of inputs, the difference will be equal to the value of a newborn calf.

Equation (1) presents the choices facing a producer in simplified form. The terms specified do not allow for any variation over time in the prices of inputs or outputs, or in the level of the outputs produced. Further, the amounts produced appear independent of the inputs provided, the age of the animal, and the amounts produced of other outputs. Such complexities have been omitted for expositional reasons; they can and should be incorporated into the model when it is used for analytical purposes. In particular, livestock products are inevitably joint outputs, meaning that it is impossible for some outputs, e.g., milk, to be produced without at least some other outputs also resulting, e.g., beef. This fact means that the unit cost of producing any one output is dependent on that of producing other outputs. Nonetheless, even though the relationships are shown in a simplified form, it is easily seen that the decisions facing a livestock producer in most developing countries are complex.

In most developed countries, the production environment permits carefully (genetically) selected animals to produce a great deal of a single specialized output, e.g., milk. As a result, producers in developed countries usually find it profitable to utilize animals to produce one primary output and to place little emphasis on other outputs, e.g., traction. In contrast, in most developing countries the harsh production environment and the lower level of management makes it difficult to achieve such high production levels for individual outputs. Producers usually find it profitable to obtain a moderate amount of each of several outputs from their livestock.

Equation (1) also indicates that wherever a number of outputs are important economically, the profitability of using livestock will be related to a large number of parameters. In the case shown, the producer would need to be concerned with seven prices or values: p, c, r, v, n, l, and z; the physical productivity of the animal in five activities as represented by: w, d, m, q, and b; the level of inputs required, i; and the appropriate age of slaughter, θ. Although some of the prices are given to the producer, others like v and l may depend on his choice of farming system. Strong interdependencies should also exist among the productivities of the animal in producing different outputs.

The overall profitability of livestock assets and their particular use are likely to vary if the demand for some products, such as meat or milk, increases more rapidly than others, such as traction and manure. The ability of cattle to produce multiple outputs provides the livestock system with some capacity to shift outputs fairly easily within a small range in response to changing incentives. However, if a significant shift in the livestock product mix is desired, such as from traction to beef and/or milk, the process of changing is a time-consuming and expensive process.

Although each animal has a basic capability to produce many outputs, livestock producers all over the world have learned that they can select animals which have greater genetic capability to produce larger amounts of the desired output. Careful selection over time has resulted in development of herds which are genetically well suited for producing a desired output mix within a specific environment. However, animals which are able to produce unusually large amounts of one type of output under one set of environmental-management conditions are unlikely to produce such high levels of output when the environmental-management conditions are changed. Similarly, animals which are genetically well suited for production of a specialized output in one environment, e.g., traction on small farms in Asia, are unlikely to be fully efficient producers of other outputs, e.g., milk, under any environmental-management condition. Although numerous animal species can produce a moderate level of several outputs from a moderate set of production inputs, it is difficult, if not impossible, to obtain animals with the genetic potential to achieve high levels of every type of output (Vercoe and Frisch, 1980). As a result, the shift from one desired output to another usually requires a shift both in environmental-management conditions and also in the genetic makeup of the livestock herd. The need to bring about nearly simultaneous changes in these closely interrelated factors has made livestock development more difficult than agricultural development in many developing regions.

Changes in the desired output mix also usually have significant impact on the age-sex composition of the herd. Because animals must reproduce if the livestock system is to be sustained, and do so with approximate male-female parity, any change made in the use of animals of a given age and sex will have repercussions on the availability, cost, and uses of other animals. If bullocks are required for draft use, for example, cows are required to produce replacement calves. The value of the calves must be sufficiently high to ensure that maintaining the cows is profitable. If less draft power is suddenly required, other things being equal, the number of both bullocks and cows will decline (Jarvis, 1982). Changes occurring in one aspect of the system, i.e., in the value of draft, milk, or beef, will have ramifications throughout the cattle system even on those animals that at first appear not to be used for such production. The indirect as well as the direct effects of changes in prices need to be considered in predicting the functioning of a livestock system.

EXAMPLES OF THE CONTRIBUTIONS MADE BY LIVESTOCK IN SPECIFIC AGRICULTURAL SYSTEMS AND COUNTRIES

Empirically, the uses of livestock vary significantly across countries and even across regions within countries. A number of examples will be discussed below to indicate the striking diversity of livestock use. Each of the examples refers cattle, only one of the many types of livestock assets. For limitations of space, only the most essential aspects of each example are described.

Beef (Uruguay)

Cattle production has been the predominant form of land use in Latin America since its colonization by the Spanish and Portuguese in the 16th century. Cattle production fits well into the region's resource endowment: ample land, frequently with limitations on crop production because of soil fertility or topography, a low population density, and limited infrastructure. Latin America now has approximately 318 million cattle, or 25% of the world's stock (Seré and Jarvis, 1988).

Beef is the primary output from cattle in most regions of Latin America, although considerable milk is also produced. Hides are an important by-product, accounting for about 10% of total livestock output. Animal traction is important on small farms in some regions. Cattle are also bred, producing calves.

Although beef ranching is important throughout the region, ranching probably has its greatest relative economic importance in Uruguay. Located on the Atlantic coast of South America between Argentina and Brazil, Uruguay is predominantly composed of gently undulating grasslands. Only about 30% of its area is cultivable and little of this can be continuously cropped because its soils are thin and of low fertility. Uruguay therefore dedicates most of its area to ruminant livestock production, primarily cattle and sheep. Production occurs on extensive ranches, with a minimum of management and other variable inputs. Over two-thirds of cattle and sheep are located on ranches larger than 1000 hectares.

Cattle in Uruguay are a means of converting extensive grasslands into beef (and milk to a lesser degree) for domestic consumption and export. Hides provide a valuable industrial input. Livestock are not significantly integrated with agriculture and animal traction is not important. Manure helps to maintain pasture soil fertility, but is not widely applied to crops.

Livestock provide important export revenues, with meat, hides, leather, wool, and wool and leather-based industries providing the bulk of Uruguayan exports. During the last 25 years, beef accounted directly for about 5% of Uruguay's GNP, 25% of total exports, and directly and indirectly, a similar amount of national employment. Cattle ranching employs relatively few workers, but the industries which supply the beef sector and process its output employ many and involve key components of the Uruguayan manufacturing sector, i.e., meat packing, leather curing, and shoe and other leather goods production.

Beef is also Uruguay's most important wage good. Per capita beef consumption averages about 160 pounds a year. Beef accounted for more than 75% of the total meat and fish consumed, and for about 7% of the average family's total expenditures. More was spent on beef by urban families than on any other food item, even in the lowest income quartile. Beef is an important source of both calories and protein and beef's availability and price are important determinants of consumer welfare, real wage demands, and inflationary pressures (Jarvis, 1982a). Milk is also an important consumer good and small amounts are exported.

Although livestock and agriculture are not closely integrated, efforts have been made during the last two decades to develop systems under which fertilized grass-legume pastures could be rotated with crops. The costs of establishing improved pastures are reduced when the pastures are planted in the fertilized crop stubble, and the improved pastures increase agricultural yields and improve soil structure. These efforts have had limited success, in part because the spread of bermuda grass has reduced the economic life of improved pastures, but have performed best in areas where extensive rice production requires frequent fallowing.

The government has also sought to introduce extensive grass-legume pastures as a means of increasing and improving nutrition in extensive areas. Nutrition is the primary constraint to the expansion of production. The adoption of improved pastures, introduced in the late 1950s, reached a ceiling which is much lower than was initially hoped, mainly because the imported technology has not been adequately adapted to Uruguayan conditions, because ranch management is insufficiently intensive, and because the output/input price ratio is too low (Jarvis, 1980).

Uruguay's economic reliance on pastoral products, especially beef, has led to several policy problems, the most important of which has been the need to choose between higher beef prices -- which would encourage output, restrict consumption, and increase exports -- and lower beef prices -- which would improve consumer welfare and nutrition and restrain wages and inflation. Historically, governments have vacillated between higher and lower prices, but the political strength of urban interests has usually resulted in lower prices for consumers. It should be possible to increase beef prices with less producer welfare loss -- and political resistance -- if the relative prices and the quality of poultry, pork, and mutton are improved. The need to achieve higher beef production, exports, and foreign exchange is a powerful argument for accepting higher beef prices.

The beef sector in most countries experiences pronounced fluctuations in beef prices and slaughter which are called "cattle cycles." Such fluctuations, which are unusually strong in Uruguay, introduce a serious macroeconomic problem because of beef's economic importance in production, processing, and consumption. The large fluctuations create major changes in the domestic income distribution (mainly between livestock producers and consumers), in the activity of important economic sectors, especially agriculture and meat packing, and in export and tax revenues. A desire to alleviate the effects of these "cattle cycles," which in Uruguay result largely from developed country market interventions, have led the Uruguayan government to attempt offsetting intervention in the livestock sector, with mixed results (Jarvis, 1982a; Jarvis and Medero, 1988).

Beef and Milk (Central America)

In tropical Latin America, especially in the lowlands, cattle are often used to produce beef and milk jointly. Milk becomes an important joint product wherever the demand for milk is sufficient to justify the cost of milking and where ambient stress reduces the production levels of specialized dairy animals. Milk demand at the farm level in such areas depends mainly on population density and the cost of transportation. Farm labor costs depend mainly on the overall demand for agricultural labor, but they are usually lower on small farms. Environmental stress is especially high in tropical areas due to high temperatures, greater disease and parasite threat, and the lower quality of pasture forage. Under these circumstances, it is genetically difficult to obtain an animal which can achieve either high beef weight gain or high milk production. Therefore, a breed with intermediate levels of production of both weight gain and milk production becomes more profitable (Preston 1977; Seré 1981; Jarvis, 1986). In such circumstances, beef production can actually increase as milk is produced, at least within an economically important range. Beef can be produced at lower cost because part of the costs of raising and maintaining a cow to produce the beef calf are now borne by milk sales (Jarvis, 1986).

A high proportion of the cows milked in tropical Latin America are dual-purpose cows. Although the annual milk yields from such cows are only about one-fourth that of specialized dairy cows in the same region, roughly 40% of total milk is from dual purpose cows (Seré and Rivas, 1986).

Increased domestic milk production through dual-purpose systems avoids imports of milk, provides significant employment, and provides consumers with milk at lower price and/or higher quality than would be otherwise available. Milk imports have steadily increased in tropical Latin America, but the region has been able to remain largely self-sufficient in milk production (importing about 5% of total consumption) by maintaining real milk prices above (currently depressed) world levels.

Milking beef cattle has some disadvantages: the milk production capacity of beef cattle is low, labor costs are substantial because beef cattle are more difficult to milk, and milking reduces calf growth. Nonetheless, von Oven (1969) found that in Venezuela milking beef cattle was economical even for ranches with as many as 500 cows because the milk price was high relative to beef price and wages were low. Careful cross-breeding in recent years between criollo or zebu cattle and dairy breeds has created a better dual-purpose animal, raised milk productivity, and increased the profitability of dual-purpose production even though real wages have increased.

Dual-purpose production has special advantages for the smallholder. In comparison with specialized beef production, milk offers a regular rather than a highly seasonal income -- an important advantage to producers with limited cash and capital and little access to formal credit markets. Milk production, because it is more labor-intensive, offers a return to labor which might otherwise produce little. Diversified farm production reduces overall risk. And milk production may result in by-products which can be used in other farm activities, e.g., stall manure for crops and whey for feeding swine (Jarvis, 1986). Because milk production responds more strongly to improved feed rations than does beef production, cows which are milked are usually better fed and this has a positive effect on fertility, increasing weaning rates.

Joint beef-milk production differs from specialized beef production in its more intense input and more rigorous marketing requirements. Fresh milk must be sold daily. Refrigerated trucks are needed and transport time from the farm gate to the collecting and processing facilities must be short. The primary requirement for increased milk production in most countries of the region is the organization of marketing, processing, and distribution facilities.

Development of dual-purpose production has had positive social impact in tropical regions. Milking dual-purpose animals makes smaller farms viable, gives an impetus to rural electrification for refrigeration, and requires better animal nutrition and health (and thus encourages farm intensification and closer links with nonagricultural service industries). Management by a resident owner is usually key to success. Thus, dual-purpose production has had substantial social as well as economic advantages by encouraging road and transport development, electrification, owner management, higher labor inputs per hectare of land use, smaller farm units, more continuous market interaction, and greater regional value-added through construction of processing facilities (Jarvis, 1986).

Milk, Beef, Blood, Prestige, and Social Bonding (Sudan)

Pastoralism is the dominant mode of livestock production throughout extensive range areas in Africa where rainfall is low and highly variable, making settled agriculture and/or livestock production extremely risky. The principal production risk for a specific area is that no rain will fall. However, cattle can be guided by their herders to areas where rain has recently fallen and where pasture is available.

The need for access to large areas of land in order to ensure access to sufficient pasture is an important reason for the evolution of "common" range systems. In such systems, a group of pastoralists share land, with all being able to move about with their herds in search of the best forage. If the system is to work well, pastoralists must have a well-defined membership group with clear (albeit sometimes complex) rules of access to pasture and water. If group membership and/or the rules of access become unclear or ineffective, the system may tend toward an "open" access system in which no limits are placed on the number of herders (and animals) using the land. In this case, the economic value of pasture is likely to be severely diminished or lost altogether.

Pastoralism is widely identified with grazing large herds of cattle on the extensive range. However, pastoralism is highly labor-intensive -- mainly seeking out areas in which good forage is available, protecting animals from predators, treating animals for disease and parasites, watering animals at wells and, especially, milking.

Milk is the primary economic output of pastoralists, both for direct consumption and for barter, though animals are also marketed for beef. Blood is taken from animals for consumption during periods of low milk production and for ceremonial purposes (Dahl and Hjort, 1976). Livestock producers in nearly all regions of the world associate/gain prestige from the number and quality of their animals, but the prestige from owning cattle of high quality is probably particularly important among African pastoralists. Pastoralists generally function within societies where there are few other private assets. Cattle, being practically the only productive assets available, traditionally played an important role as a monetary instrument in society: a store of value, a medium of exchange, and an investment good. Use of animals as a source of prestige and/or as a store of value will decrease output of beef and milk to some small degree, but, as shown by the demand for such "outputs," use of the animals to produce such services will increase the overall return to the livestock asset (Jarvis, 1981). The exchange of livestock among kin and friends also provides insurance against drought and disease risks and is an indicator of mutual trust, contributing to social bonding.

In most areas, pastoralism is probably more productive in terms of the value of total output of beef and milk per hectare of land than is ranching beef (Jarvis, 1984; De Ridder and Waggenaar, 1984). The production function faced by beef ranchers is quite different from that faced by pastoralists. The pastoralists utilize much more labor and extract a larger number of joint products for direct use, especially milk. Beef is produced from cull animals, both steers and cows, but accounts for a relatively small proportion of output (Dahl and Hjort, 1976).

Pastoralists often barter milk and beef with agriculturalists for grain, which is a cheaper source of energy. Manure is used for fuel, and is also left on the fields of agriculturalists when seasonal migrations take livestock into settled areas. Agriculturalists sometimes pay herders to graze their animals overnight on their fields.

In systems in which land is communally owned, livestock ownership provides usufruct rights to land which are otherwise lost. Mechanisms are needed in such systems to ensure that all individuals having grazing access also have livestock. In pastoralist systems, livestock ownership traditionally belonged to kinship groups which used force to maintain their hegemony over a particular region. Complex societal rules and livestock exchanges existed within such groups to ensure that individuals who lost their animals to disaster, such as drought or disease, could reconstitute their herd. Such mechanisms have been breaking down in recent years, largely because pastoralist populations have gradually expanded while range has been lost to the spread of sedentary agriculture (by other tribal groups).

Under these conditions, the average herd has been shrinking and traditional mechanisms have proved insufficient to reconstitute the herds of many individuals following disaster. Wealthy individuals, frequently located in urban areas and able to better diversify risks through other economic activities, are accumulating animals and hiring others to herd them. Gradually, as a higher proportion of total herds are owned by such individuals who seek a more marketable output, greater emphasis is being placed on beef production. The increased reliance on beef cattle is also consistent with a greater emphasis on property rights in land.

Efforts to obtain increased amounts of beef, for example, for consumption by urban residents and for export, from areas utilized by pastoralists face a fundamental problem. Pastoralists usually obtain higher total output from the range they use than would commercial ranchers (Sandford, 1982; Jarvis, 1984). Higher outputs of beef are therefore feasible only if livestock sector resources are channeled increasingly toward beef rather than milk. This shift will be profitable only if there is a substantial increase in the value of beef vis-a-vis other commodities.

Draft, Manure, and Milk (India)

In much of Asia, cattle are used mainly for animal traction on small farms. Cattle are particularly useful to the extent that they feed on roughages and farm by-products that cannot be fed to humans or utilized for other purposes. In India, for example, cattle are fed principally on wheat and rice straws: half the gross energy present in the organic matter of India's rice and wheat crops is found in such straws (Ranjan, 1978). This energy would be largely wasted if it were not consumed by ruminants. Lands unsuitable for cropping, i.e., local commons, roadsides, and forest or public lands, as well as fallows, provide additional feed.

Due to cultural and religious traditions, many individuals in India prefer not to eat beef and/or to kill cattle. Beef, normally a major by-product from large ruminants, is of little value (in many areas, such beef from such cattle is consumed by the Moslem minority). Nonetheless, farmers require some means to cultivate, most farms are too small to justify mechanization, and they produce limited amounts of forage. The value from draft and manure must therefore be sufficient to justify maintaining the animal, and this in fact occurs where livestock are kept.

Sandford (1978) estimates that beef accounts for only about 1% of the value of cattle output in India, with 60 to 80% received as draft services, 10 to 20% as manure, 7 to 15% as milk, and 1 to 2% as hides. Incorporation of manure into fields and garden areas, and therefore improving soil fertility and structure, is often essential to maintaining agricultural production. However, with no incentive to slaughter the animal, there is a strong incentive for producers to simply abandon their animals when their economic life as draft animals has ended, imposing an externality on other producers through need to protect their crops and share the communal grazing with rogue animals (Jarvis, 1982b).

The cattle breeds used in India have evolved to provide efficient draft service under circumstances that are frequently harsh: heat, humidity, disease, external and internal parasites, poor feed, and relatively limited husbandry practices. These cattle need to be able to survive on meager rations -- because the production of additional fodder would reduce the food available for human consumption or sale -- and yet have sufficient strength to perform the needed draft functions.

On most smallholder farms in Asia, draft animals are required for plowing only for a limited number of weeks in the year, and, except for this period, the animals may be quite ill-fed. Although the strength and endurance of the animal can be increased through improved feed, owners will provide such feed only to the extent that increased strength is needed for the task at hand. Increased feed or other maintenance expenditures may not be profitable given the limited scope for higher animal physical productivity, particularly where beef has little or no value. On the other hand, where milk is an important component of livestock output, higher quantity and quality feed is required on a regular basis.

Manure is used for fuel in many areas where firewood has become increasingly scarce and expensive. In India and in China, household biogas production from cattle manure has assumed some importance -- about 1% of rural homes in China (Treichler, 1988).

Draft, Beef, Milk, and Manure (Indonesia)

In Indonesia, as well as in parts of Africa and other parts of Asia, beef is consumed and each of the four outputs mentioned is economically important. Milk is provided by female animals and animal traction services are provided mainly by male animals, with animals of each sex also providing beef, manure, and calves. However, in some areas female animals are also used for traction.

In areas where cattle are used for traction, it is economically very important that the animal is producing beef while it is growing to the size and strength required for pulling implements. The beef which is obtained when the animal is slaughtered, after providing draft services for several years, is crucial to making the overall use of the animal profitable.

The number of draft animals in Indonesia has been declining, despite an increase in agricultural production. This decrease appears related to a decrease in plot size, an increase in the opportunity cost of labor (especially for children), and a decrease in the cost of machinery. In particular, as plot size decreases, the need for draft services diminishes, and there is a tendency to substitute female for male animals, with the former being used for draft, manure, milk, beef, and breeding.

Efforts are being made to introduce animal traction into many areas of sedentary agriculture in Africa (Pingali *et al.*, 1987). In such efforts, production of beef and manure as well as draft power has been crucial to economic use of animals.

Beef and Breeding (Korea)

Cattle traditionally were used in Korea mainly for draft and manure. Farm size is small, feed by-products are limited, and feedgrains are expensive. In recent years, rising incomes have led to rapidly rising demand for beef, and industrial development has led to much cheaper supply of machine traction, such as tillers. Faced with a feed constraint, smallholders have found it profitable to substitute machinery for animal traction, and to use their limited forage for breeding stock. This tendency has been encouraged by government policy which imposes high tariffs on imported beef, thus making calves more valuable products. The calves produced by small farmers are sold to feedlots, where they are fattened on imported grain. Because the total available forage is so limited, the supply curve for beef output in Korea became very inelastic once the initial draft herd on small farms was replaced by a breeding herd (Jarvis, 1982b). Subsequent increases in meat production are therefore likely to come predominantly from poultry and pork, each of which can provide increased supply of meat at relatively constant cost.

Poultry (Mexico)

Although the previous examples deal solely with cattle production, poultry production has been rising rapidly throughout most of the developing world. For example, the growth of income, population, and urbanization in Mexico has led to a rapid rise in meat demand during the last three decades. Beef, pork, and poultry production have each grown rapidly in response. The pork and poultry industry have provided Mexico with an easily expandable source of meat at an inexpensive and steadily declining price. The income elasticity of poultry consumption is high in Mexico and poultry is becoming one of the main sources of an improved and palatable diet for urban residents. Poultry is sold in pieces which are easily used by the family.

Of the three meats, the price of poultry has decreased more rapidly than that of any other meat in Mexico during the last 25 years, due to rapid technological and structural change in the industry. Most of the technological change has been generated in the United States and the EEC, and has been transferred to Mexico. The same phenomena has been repeated in many Latin American countries and in even greater degree in some, i.e., Brazil.

The rapid rate of technical change in poultry contrasts markedly with the relatively slow rate of change in the cattle sector throughout Latin America (and the rest of the developing world). Basically, this difference results from the much greater ability to create a controlled environment for industrial-type enterprises like poultry, in which management skills also have high payoff, versus the difficulty of making changes in millions of small farms.

The substantial decline in the price of poultry has implied a gain for poultry consumers (Perali, 1988). Both rich and poor have benefited from the decline in poultry's price (and the improvement in its quality), but roughly in proportion to the amount consumed. Such gains have special benefit since they are probably not accessible without domestic production, at least in some degree, because of the problems of distributing and marketing fresh/frozen international chicken (Carlos Seré, personal communication).

Poultry and pork consumption have risen because these two products can be produced relatively inexpensively with consumption of feedgrains such as sorghum and soybeans. The increase in poultry consumption has led to a substantial increase in the demand for poultry feed, and thus for feedgrains and industrial by-products. The Mexican sorghum industry expanded dramatically during the last 20 years, but this expansion would have taken place whether or not domestic production of poultry had increased because surplus production could have been easily exported (Perali, 1988).

CONCLUSIONS AND IMPLICATIONS FOR LIVESTOCK DEVELOPMENT STRATEGIES

The examples given indicate that the same type of livestock are used in different ways in different countries, while different livestock are often used to produce similar products in the same country. Environmental circumstances and economic incentives play a powerful role in determining the patterns which emerge. Thus, one of the main responsibilities of policymakers is to ensure that economic markets work well so that livestock producers receive appropriate signals regarding resource allocation. Similarly, the sensitivity of the output mix to economic and technical factors indicates that, when formulating livestock development strategies, it is very important to have a clear understanding both of the various constraints on the production of different outputs and also of the demand for different outputs.

Given the distinction between the abilities of ruminants and nonruminants in terms of feed conversion, the major opportunities for the use of livestock to affect "agricultural" development is with ruminants, that is, ruminants have greater potential for integration with agricultural activities. However, multipurpose animals respond less dramatically in terms of any one output to changes the inputs provided, and thus are less likely to provide major changes in profitability. Livestock development in these conditions is more complex and more difficult.

The opportunity for the use of nonruminants is largely "industrial" and is driven more by consumer meat demand. However, the latter are likely to provide a powerful indirect stimulant to agricultural development by providing a strong derived demand for feedgrains. In addition, backyard and small-scale pig and poultry producers have an opportunity to utilize excess labor and feed resources to improve their household diet and obtain cash sales. However, the management costs of livestock production are significant and this activity is highly competitive.

REFERENCES

Dahl, G., and A. Hjort. 1976. *Having Herds.* Department of Social Anthropology, University of Stockholm.

De Ridder, N., and K.T. Wagenaar. 1984. A comparison between the productivity of traditional livestock systems and ranching in Eastern Botwsana. *ILCA Newsletter* 3:5-7. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

Jarvis, L.S. 1974. Cattle as capital goods and ranchers as portfolio managers: An application to the Argentine cattle sector. *Journal of Political Economy* (May-June), 489-520.

_______. 1980. Economic, ecological and management factors affecting the adoption of improved pastures in Uruguay. In *Conference Proceedings of the Fourth World Conference on Animal Production*, edited by L.S. Verde and A. Fernandez, vol. 1. Argentine Association of Animal Production, Buenos Aires.

_______. 1981. Cattle as a store of wealth in Swaziland: A comment. *American Journal of Agricultural Economics* 62(3) (August), 606-13.

_______. 1982a. Tercero y cuarto proyectos del Banco Mundial para desarrollar el sector ganadero del Uruguay. In *La Ganadería de Carne en el Uruguay*, by L. Jarvis, C. Perez, and J. Secco. CIAT, Cali, Colombia.

_______. 1982b. To beef or not to beef: Portfolio choices of Asian smallholder cattle producers. In *Livestock in Asia: Issues and Policies*, edited by J.C. Fine and R.G. Lattimore. International Development Research Center, Ottawa, Canada.

_______. 1984. Overgrazing and range degradation in Africa: Is there need and scope for government control of livestock numbers? Paper presented to Conference on Livestock Policy in Africa, International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia.

_______. 1986. *Livestock Development in Latin America.* The World Bank, Washington, D.C.

_______. 1987. *Smallholder Dimension of Livestock Development: A Review of World Bank Experience.* Department of Agricultural Economics Working Paper, University of California, Davis. Processed.

Jarvis, L.S., and M. Medero. 1988. Domestic beef price stabilization in a beef exporting country: Uruguay 1961-1986. Invited paper for presentation at the XX International Conference of Agricultural Economists, Buenos Aires, August 24-31, 1988.

Perali, C.F. 1988. The welfare impact of the development of the Mexican egg and poultry industry. Unpublished Ph.D. thesis, University of California, Davis.

Pingali, P., Y. Bigot, and H. Binswanger. 1987. *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa.* The World Bank, Washington, D.C.

Preston, T.R. 1977. A strategy for cattle production in the tropics. *World Animal Review* 21:11-17.

Rivas, L., C. Seré, L.R. Sanint, and J.L. Cordeu. 1987. *Poultry Versus Beef: Changing Meat Consumption Patterns in the Latin American Tropics.* Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. Processed.

Sandford, . 1982. Livestock in the communal areas of Zimbabwe. A report prepared for the Ministry of Lands, Resettlement and Rural Development, Zimbabwe. Processed.

Seré, C. 1981. Primera aproximación a una clasificación de sistemas de producción pecuaria en suelos ácidos del trópico Latinoamericano. Informe económico Colombia. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. Processed.

Seré, C., and L.S. Jarvis. 1988. The betting line on beef: Ex-ante estimates of improved pasture research benefits for the Latin American Tropics. Paper presented to the Rutgers University-ISNAR Agricultural Technology Workshop, Rutgers University, July 5-7, 1988.

Seré, C., and L. Rivas. 1987. The advantages and disadvantages of promoting expanded dairy production in dual purpose herds: Evidence from Latin America. *Trends in CIAT Commodities.* Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.

Treichler, R. 1988. The adoption and use of biogas digestors in India. Term paper for International Agricultural Development 201, University of California, Davis. Processed.

Vercoe, J.E., and J.E. Frisch. 1980. Animal breeding and genetics with particular reference to beef cattle in the tropics. In *Conference Proceedings of the Fourth World Conference on Animal Production*, edited by L.S. Verde and A. Fernandez, vol. 1. Argentine Association of Animal Production, Buenos Aires.

von Oven, R.O. 1969. Consideraciones económicas sobre el ordeno de vacas de carne en el tropico Sudamericano. *Ganagrinco* (Caracas) 3,4:1-15.

ROLE OF ANIMAL AGRICULTURE IN FARM ENTERPRISES/HOUSEHOLD PRODUCTION AND LINKAGE TO REGIONAL AND NATIONAL ECONOMIES

Benjamin Quijandria, Ph.D.
Center for Research and Agricultural Development of Perú

BACKGROUND

Livestock and small farm animals are widely distributed all over the world, with important economic participation in household and small farm enterprises, as component of farming systems. However, the acknowledgement of this fact has taken some time to be fully appreciated within the scientific community, farming systems specialists, international development agencies, and even national policymakers of the agricultural sector in developing countries. The recognition of its economic importance, not only at the family level, but at regional and national stage, has still a long way to go.

Traditional economic analyses have underrated and underevaluated the role of household and small farm livestock activities, generating a significant bias in favor of the cropping segment of small farms, in which increasing production and productivity appears as an attainable goal. Limited farm size, very limited or unknown nutritional resources, and "uncommon" farmers' goals toward livestock have led to the erroneous concept that there is little potential or room for economic or productive improvements. Furthermore, the fact that herding, grazing, and management are assigned to women and children, while men are devoted to crops, has led to the conclusion that livestock raising is a second rate activity within the family economy. However, a worldwide distribution of domestic animals, with a large percentage owned by subsistence or small farmers, requires a much needed reevaluation of its importance.

Table 1 presents the swine, goats, sheep, and cattle population in the world and in selected areas. Developing countries account for 66.7% of the world population of cattle, 55.1% of swine, 53.3% of sheep, and 94.0% of goats. These species are normally associated with either pastoralist societies, or in mixed crop-animal production systems that comprise over 80% of the small farm population of the world (McDowell and Hildebrand, 1980; FAO, 1983).

Figures presented in Table 1 underscore the importance of small animal species in particular, and of livestock in general, in small farm economies. In Latin America, other well-known species also participate in small farmer production systems, they include guinea pigs, South American camelids, capibaras and even lizards. Their distribution is mainly with small farm production, subsistence farming, and mixed crop-animal agriculture.

Another interesting fact is that, even though small animal species have a worldwide distribution, ecological adaptation to particular climates and/or altitudinal levels, clearly distinguish species adapted to particular conditions. Such is the case of the goat in tropical dryland regions, or the alpaca in the high tundra (>3,500 m above sea level). Within these two ecological extremes, swine, goats, and hair sheep, are found over a wide variety of ecological subregions, playing specific roles within each particular system (FAO, 1985; Gonzalez, 1979; Quijandria *et al.*, 1987).

Table 1. Swine, goat, and sheep populations in the world and the tropics and subtropics, 1986 (in thousands)

	Swine			Sheep			Goats			Cattle		
	Head	%		Head	%		Head	%		Head	%	
World Total	882,443	100		1,145,690	100		492,755	100		1,268,934	100	
Developed Countries M.E.[1]	192,528	21.8		362,968	31.6		20,404	4.1		268,961	21.1	
Developing Countries M.E.[1]	131,515	14.8	100	493,323	43.1	100	396,456	80.4	100	787,289	62.0	100
Africa	10,486		7.9	133,565		27.1	136,504		34.4	140,865		17.9
Latin America	81,507		61.9	117,544		23.8	31,651		7.9	317,608		40.3
Near East	310		0.2	154,206		31.2	61,632		15.5	56,688		7.2
Far East	37,229		28.3	87,981		17.8	166,542		42.0	271,542		34.5
Other	1,982		1.7	28		0.1	127		0.2	586		0.1
Centrally Planned	498,400	56.3		289,399	25.3		75,332	15.5		212,683	16.8	
Total Developed Countries	335,579		44.9	544,528		46.7	28,991		6.0	423,145		33.3
Total Developing Countries	486,864		55.1	611,162		53.3	463,201		94.0	845,789		66.7

[1] Market economies.

Source: FAO. 1986. Production Network. Food and Agriculture Organization of the United Nations.

The role of cattle and small animal species varies within farming systems patterns according to the ecological and socioeconomic conditions of regions and countries. The definition of the context in which animal production takes place is very important in order to prepare rural development, research and extension, credit, price, and market policies, and evaluate its impact in rural, regional, and national development.

ANIMAL SPECIES AND PRODUCTION SYSTEMS

The systems approach has been proposed to study ways of overcoming the technological limitations encountered in small/medium farms. This requires a holistic, multidisciplinary study of the farm, including its resources, management, and outputs. Farmer participation, his goals and aspirations are key elements in this approach. With regard to the improvement of the animal components it requires the study of its genetics, feeding, management, health, and production economics. The interaction with the other farm components and the exogenous factors (environment, markets, policies) is also considered.

The description and understanding how different animal species are raised, fed, managed, and marketed, coupled with information on farmers' goals and their views on roles played by animals within household economics, constitute the initial baseline information required to give proper value to animal agriculture and its impact in rural economies, and to define its importance and subsequent policies for rural development.

Several publications (CATIE, 1987; FAO, 1980, 1983; Gonzalez, 1979; Jimenez and Hobbs, 1985; McDowell and Hildebrand, 1980; Perevolotsky, 1984 and Quijandria, 1987; Quijandria *et al.*, 1987; among others) have tried to present either general or specific descriptions of farming systems prevalent in different regions or countries, with particular reference to animal agriculture. One of the most complete descriptions of mixed farming systems for Asia, Africa, and Latin America has been prepared by McDowell and Hildebrand (1980).

Table 2 presents some characteristics of prevailing production patterns in Latin America. Classification of systems have been done basically on: ecological location, crop-animal interactions, market orientation, farm size, and the relative importance of livestock in the economy of each group.

In Latin America four main groups have been identified: a) large farms with perennial crops, with limited importance of livestock production; b) large farms with commercial annual crops, with moderate importance of livestock production; c) commercial livestock production, with two categories: large and medium size enterprises, and d) mixed crop-animal systems.

The last group represents the largest number of either production units or farmers throughout Latin America. Mixed farming, by small and medium size private farms, subsistence farmers, and peasant communities own between 60 and 80% of cattle, sheep, goats, swine, and South American camelids in Latin America and the Caribbean, with limited variations within countries.

Herd sizes are normally small in most mixed systems, with the exception of pastoralist societies. Swine may vary from 1 to 20 head depending on the system, location, and feeding resources available (Quijandria, 1981). Sheep herds range from 10 to 60 animals, the smallest number associated

Table 2. Gross and net income by activity and farm size in Perú (constant units, 1984)

Farm size (ha)	Annual gross income (Ps)	Income source			Self consumption		Average expenditures		Average annual net income
		Crops	Anim.	%	Crops	Anim.	Crops	Anim.	
Landless	1,908	-	1,894	99	-	284	-	146	1,744
<1	871	544	364	42	296	194	125	107	623
1- 1.9	1,543	1,076	518	34	491	293	260	139	1,129
2- 4.9	2,658	2,158	615	23	674	289	676	278	1,693
5- 9.9	4,638	3,613	1,165	25	807	365	1,089	336	3,036
10- 19.9	7,333	5,808	1,800	25	981	595	1,995	461	4,629
20- 49.9	10,121	9,039	1,692	17	1,172	583	3,018	461	6,246
≥50	10,644	8,861	4,436	42	1,596	899	3,718	857	6,426

Source: Quijandria, 1987.

with a more intensive agricultural component; and the largest number with regions with some agriculture but with access to grazing land, communal ranges, or other sources of forages (Quijandria, 1987; Quijandria *et al.*, 1987; Winrock International, 1976). Goat herds may vary in size from 10 to 250, the former associated with intensive agricultural systems and the latter to pastoralist societies located close to or in extensive rangeland areas. These may vary from tropical dry savannahs typical of northeast Brazil, Western Venezuela, and northern Perú; to some of the interandean valleys of Perú and Bolivia (Winrock International, 1976; Perevolotsky, 1984; Gonzalez, 1979; Quijandria *et al.*, 1987).

Cattle herds may vary in size from 2 to 20 in small farm enterprises and household production. It has been estimated that over 60% of dairy production in Central America is derived from medium and small farm sizes (Quijandria, 1976). The same holds true for dairy producing areas in Perú, Colombia, Bolivia, and Ecuador. In these specialized dairy areas herd sizes are on the average 15 head of cattle.

In subsistence farming cattle herd sizes vary from 2 to 6 on the average. Some of these animals (castrated males and bulls) are used as oxen, which are a very important part of the economic resources of farmers. The importance of cattle is indicated by the first priority given to them for the access of nutritional resources in Andean countries (Quijandria *et al.*, 1987).

Cattle is numerically the most important domestic species in developing countries (Table 1). In some regions the cattle in the hands of small farmers constitute very important proportions of the national totals. Thus, taking Central America as a whole, 15% of the total cattle population is found on farms of less than 7 ha, and 37% of the total on properties smaller than 42 ha.

In most farms in the tropics, cattle is of dual or even triple purpose. In Latin America, for example, dual-purpose animals constitute 25 to 94% (unweighted mean: 70%) of the national milked populations in 15 tropical countries, and that milk derived from them accounted for 6 to 75% (mean: 40%) of the total production. The dual-purpose systems in Latin America are particularly common on small farms. Thus, the specialized populations of dairy and beef animals tend to be concentrated in the medium and large commercial herds, located principally in the temperate regions (dairy) or lowland tropical areas (beef).

The dual-purpose system so prevalent in Latin America is typically based on crossbred cattle of mixed European, Zebu, and criollo inheritance. Cows are generally milked with calf at foot, sometimes only seasonally. Feeding is based principally on pastures with occasional supplementation with crop residues, but very little purchased feed inputs. On small farms, males may be retained for work or otherwise sold for meat at ages which vary widely between herds. Health care is usually deficient and very few farms keep production records. Despite the low levels of production obtained, there is a wide consensus of opinion but these herds offer the best opportunity for increasing the production of meat and milk at reasonable costs throughout the tropical region, and that their development can make an important contribution to improve standards of living of the neediest members of the rural populations.

This first general description indicates that livestock development efforts will have to deal with small number of animals within farms, wide ecological settings, variable nutritional resources, specific and uncommon economic roles, different market strategies, and especially very particular farmer goals.

ROLE OF LIVESTOCK AND SMALL ANIMALS IN FARMING SYSTEMS

Some scientists and most governmental policymakers, in analyzing the role of livestock in small farming systems, tend to conclude that the same objectives, strategies, and policies applied to market-oriented operations are applicable. Thus, programs and policies often fail to promote livestock development in rural areas.

The economic rationality of the small animal component, within a given farming system, tends in many cases to modify the role and objectives of animal species, adapting them to particular needs. Modifications in many cases go against goals normally set by scientists and commercial operators in market-oriented enterprises. Changes in livestock raising patterns normally fit specific requirements and needs of the rural family, and most evaluations tend to overlook these particular economic outputs (Winrock International, 1976; Gonzalez, 1979; Quijandria, 1987).

Even though cattle, swine, sheep, goats, guinea pigs, and alpacas are generally raised for either meat, milk, wool, or fiber production, an additional set of objectives has been identified in particular farming systems. Pastoralists societies tend to utilize and market animal products as a way of income, through the selling of live animals or by-products. However, as systems gradually move into a mixed pattern, additional roles and objectives are placed on animals, and in many cases those roles tend to have priorities over the traditional meat, milk, wool, and fiber production (McDowell and Hildebrand, 1980).

In addition, important economic traits for small animals will include the production of organic fertilizer, fuel, use of marginal nutritional resources, use of marginal family labor, entertainment (fighting rams in Indonesia), and live animal savings. Even though it is not common for small animal species, in some regions of the world draft power is also obtained from either rams or bucks for the transportation in small carts of family products to the market. The same is applicable to llama raising in the Andean highlands. With cattle, draft power is a permanent contribution to small farmers economies.

Risk avoidance is another economic role of livestock, however poorly understood and not economically accounted for. Risks are of climatic and economic nature, affecting small farm production throughout the years. A way of limiting risks is by a diversification of crops and animal species within the territory of the rural family.

For this reason, livestock, and especially small animals species, play different roles in the economy of the developed world and in that of the underdeveloped Third World. In the first case, livestock provide a contribution to human diet, a means of harvesting the product of photosynthesis, and a place in the general market economy for those involved in livestock and small animal production. In developing countries, the primary function of livestock is as a buffer between human populations and disaster. At subsistence level, livestock constitute a standing reservoir of food which can see the human population through at least short-term catastrophes. With the population growth in developing countries, this role as buffer food source may therefore become more common rather than less important (Cunningham, 1982).

The contrast between these two major objectives for livestock and small animals means that there are different genetic pressures on animal populations. In the developed world the pressure for increased productivity per animal, often in a highly protected environment, will persist. In the developing world, in which human and animal populations are most at risk, there will be little room for intensive selection pressures of this kind, and the traditional evolutionary pressures for survival in the face of adversity might even be intensified. Under these conditions, more complicated interactions between production and fitness traits will be often found (Cunningham, 1982).

Generally, small animal enterprises and household raising, in addition to their traditional role, will be directed toward:

- Provision of fuel
- Production of organic fertilizer
- Production for home transformation for use or consumption
- Use of marginal family labor
- Use of marginal nutritional resources
- Life savings

Several publications (Blond, 1983; CATIE, 1981; Cruz, 1983; Eusebio *et al.*, 1974; FAO, 1981, 1983; Quijandria, 1981, 1987) have defined each of these livestock outputs, describing its economic importance. Breeding, nutrition, health, and livestock development programs should consider these goals as part of the traits to be improved or as part of the economic outputs to be evaluated in small farm animal production.

The basis of sound breeding programs,for example, is the selection of economically important traits to be improved, either by selection or crossbreeding. Peasant farmer rationality cannot in many cases be defined by traditional economical analyses and animal agriculture plays particular roles that do not necessarily optimize either production or income, and in many cases economic analyses of whole farm income have tended to overlook monetary and special nonmonetary income derived from small animal production (McDowell and Hildebrand, 1980; Quijandria, 1987).

One of the objectives that alter traditional management practices is live animals savings (on the hoof savings). Since accumulation of animal stock is the objective, growth rate, age at market weight, and traits directly related to early marketing are not relevant. In many cases numbers of animals are preferred over efficiency of individual animal production, making a difficult setting for breeding or nutrition programs.

In conclusion, small farm, household, and family livestock and small animal raising has a set of goals that defy the traditional management, nutritional, and breeding practices known to commercial operations. The challenge of small animal agriculture is to identify economically important traits and objectives in order to adjust research, extension, and development programs to the specific purpose for which animals are raised by peasant families.

ANIMAL AGRICULTURE CONTRIBUTION TO FAMILY, REGIONAL, AND NATIONAL ECONOMIES

The exact contribution of animal agriculture to family and regional economies have been permanently underevaluated by economic analysis. Over the years, studies on mixed farming systems have provided an unbalanced gross and net income information between crops and animal production. Part of the problems are derived from the lack of knowledge of animal roles in household economics. Animals produce more than the normal outputs of milk, meat, fiber, and hides, accounting for the production of organic fertilizer, draft power, transportation, risk avoidance, and savings.

Table 2 shows the gross and net income by activities and farm size in Perú, obtained through a rural household survey supported by USAID and executed by the Ministry of Agriculture in 1984. It can be appreciated that the contribution from livestock to gross income varies from 17% in farms ranging from 20 to 49.9 ha, to 99% among landless farmers. It is evident that as the farm size gets smaller, the proportional contribution of livestock becomes more important. These results indicate that in farms from 1 to 19.9 ha at least 25% of gross income is derived from livestock activities.

However, an in-depth evaluation on the way Table 2 was calculated (Quijandria, 1987) showed that such factors as manure utilization, draft power, and transportation were considered as expenditures in crops, while they had been neglected to be included as income in the livestock component. Estimates (Quijandria, 1987) indicate that most categories of farms show a 15 to 50% increase in gross income when service factors are added in the analysis.

One aspect never considered in the economic analysis of small farms is live animal savings. In economies with large inflation rates, the yearly balance of herd size value might represent a substantial economic gain in savings for small farmers; however, these values are never calculated or included when assessing small farm income (Quijandria *et al.*, 1987).

Studies and information gathered over 4 to 5 years have shown consistently that animal agriculture income is underevaluated, but unfortunately, very few ongoing studies have been directed to: a) fully evaluate the gross income structure of small farmers, b) measure the potential benefits of animal improvement, or c) develop economic evaluation tools that can take into account nontraditional livestock economic outputs.

Also, very few success stories are reported on the impact of livestock development programs in Latin America. To illustrate the potential of reorienting and intensifying animal farm enterprises, results of a dairy development program in the lowlands of Costa Rica are presented in Table 3.

In November 1975, the Tropical Agriculture Research and Training Centre (CATIE), signed an agreement with the Costa Rican Government to develop a settlers' area located on the humid tropical lowlands (average farm size 12.5 ha). Over the next 5 years, a team of animal scientists designed a dairy production model, surveyed the area, established baseline information, and initiated an extension program with 10 farmers. Over the next 4 years, more than 100 farmers were involved, and dairy outputs evolved from 400 liters/day to more than 10,000 liters/day. Market

Table 3. Average distribution and change of gross annual income per family in Río Frío, Costa Rica, after a dairy development project, November 1975 - July 1986

	November 1975		July 1986	
Cash crops	US$	%	US$	%
Corn	64.70	6.2	85.10	2.7
Beans	73.88	7.3	124.50	3.9
Rice	127.53	12.3	-	-
Ñampi	2.00	0.2	-	-
Swine	20.24	1.9	45.10	1.4
Milk	-	-	2,955.30	92.0
Subtotal	284.35	27.9	3,210.00	100.0
Government subsidy	745.65	72.1	-	
Total	1,030.00	100.0	3,210.00	100.0

Sources: Murillo and Navarro, 1986; Quijandria, 1986.

channels had to be established. A cooling station was located nearby. The program ended in 1980.

From 1980 to 1985, the Costa Rican Government started a national dairy development program with several macro and sectorial policies supporting milk production. National outputs rose from 308.3 to 365.4 million liters in 1985 (Costa Rica, 1986. Estadistica Agraria. Banco Central de Costa Rica). The program was so successful that self-sufficiency was not only reached but a milk surplus was obtained, prices started to fall, and now the Costa Rican Government is dealing with the management of excess production.

In 1985, a group of scientists from CATIE reevaluated the area of the dairy program in the lowlands. Farmer income had tripled (Table 2), the region was undergoing an intense rate of development, wages for laborers were C/.536/day compared with C/.165 in surrounding areas (Murillo and Navarro 1986; Quijandria, 1986). The example shows that when an appropriate combination of technologies and government policies are applied, it can bring substantial improvements in farmer income and regional development.

Regional development can also influence national economies. Information from Perú and Colombia shows that medium size (10 to 30 ha) dairy farms supported by price and market policies influence growth of the Gross National Agricultural Product, and such is the case of Arequipa, Perú and El Valle, Bogota, Colombia.

The first case in Perú, a mixed system comprising dairy-onions-garlic-potatoes, has sustained 4% annual growth rate for the area, providing prosperity to the farmers of the area. The

Colombian case was based on a specialized dairy system, showing similar results in income for farmer, region, and country.

TECHNOLOGIES AND IMPROVEMENT GOALS

How much does the scientific community know about appropriate technologies for small farm enterprises or household production? Are technologies used by market-oriented enterprises applicable to small farming? What is the potential improvement of technologies on small farms? These are some of the questions frequently asked by planners and policymakers.

A rapid evaluation of demand and offer of technologies shows that some appropriate technologies are available in tropical dairy and dual-purpose cattle production, and also some for milk production from goats. In general, ruminants production in small and medium size enterprises may use a pool of available knowledge with measurable impact (Table 4). Thus, livestock development programs can use range, cultivated forages, and health changes that will have significant, economic, biological, and social impact.

The biggest technological gap lies in the area of monogastric production (swine and poultry) and sheep production at the household level. The divergence in orientation between commercial

Table 4. Evaluation of biological and economic impact of introduced technologies in selected livestock production systems

Livestock production systems	Location	Baseline production	Introduced technology: Primary	Introduced technology: Secondary	Improved production	% Increase	I.R.T.
Intensive dairy	Highlands	2,555[a]	Cultivated forages	Herd management	2,650[a]	43.8	47.8
Dual-purpose	Jungle	1,220[a]	Cultivated forages	Health	2,135[a]	75.0	41.2
Small farmer sheep	Highlands	0.8[b]	Improved range management	Health	1.2[b]	50.0	48.9
Small farmer alpaca	Highlands	1.7[c]	Health	Improved range management	2.1[c]	24.0	50.1
Small farmer goat	Northern Coast	114[d]	Improved range management	Health	180[d]	58.0	38.2

[a] liters/cow/year milk.
[b] kg/head/year wool.
[c] kg/head/year fiber.
[d] liters/doe/year milk.

Sources: Flores *et al.*, 1986; Jaramillo *et al.*, 1985; Valer, 1985; Villalobos *et al.*, 1985; Quijandria, 1987.

swine, poultry, and sheep operation, and the level of know-how used, makes it very difficult to adapt some of their practices to household levels. Differences in goals, level of investments, and intensity of production require the reevaluation of technologies, validation, or outright generation of new technologies. Seasonal lack of nutritional resources, low-quality feedstuffs, and limited herd size add to the difficulties for the ready supply of appropriate technologies. To illustrate this point, an example on swine production has been selected.

The Case of Swine Production

Traditional swine production systems around the world have changed very little over the centuries. Swine are probably the most widespread small animal species present in mixed farming systems. Their prevalence on small farms in the tropics is illustrated by the results of a survey of 5 tropical Latin American countries. Of a total of 1,582 pig farms, 73% were classified as small and contained less than 9 fattening pigs or 4 breeding sows. Similarly, data from Chile showed that 51% of the national pig herd was to be found on farms with less than 10 head.

When traditional swine production is the subject of improvement programs, a divergence usually occurs between the technologies to be introduced and farmer objectives. This is related to the role of swine on small farms. They are commonly used as a source of savings and to utilize crop and family leftovers, residues and by-products that overwise have limited value *per se*. Lard production may also be of importance since it is a staple food in many regions of the world. Swine production is a zero or limited investment operation on the farm and it has remained so for many centuries. Farmers expect the pigs to feed themselves during part of their life cycle, either through grazing, scavenging, or utilizing garbage. This orientation makes the task of selecting options for swine improvement with improved commercial technologies particularly difficult, and knowledge derived from swine breeding in commercial operations is of very limited application.

The size of small, swine herds is determined by the capacity of the system to feed the animal, so in many cases small litter size or high piglet mortality are a form of size control to keep animals in proper balance with feed resources. In these systems, the use of low-quality feeds and the usual policy of marketing when the need for cash income arises, rather than when market weights are reached, limits the importance of breeds selected for rate of growth. Furthermore, the continuing demand for lard within the household favors animals that will accumulate fat instead of lean tissue.

It has been suggested that the intensive selection of improved breeds has led to substantial physiological differences compared with the criollo or native pig (Quijandria, 1979, unpublished data). These differences can be appreciated in the digestive tract length and volume, a fact which is probably accompanied by anatomical changes within the intestine cell walls, the length and size of the caecum, and in the microbial and bacterial presence in the digestive system. These findings have been partially ratified by nutritional studies in Central America in which protein requirements of criollo and improved pigs have been determined (Gomez-Brenes *et al.*, 1974a, 1974b, 1975). Findings suggest that criollo pigs have a smaller protein requirement than improved pigs. No significant differences in growth have been obtained in criollo pigs with a limited supply of protein. Circulating serum proteins have normal levels in diets with low protein levels. The same studies also suggest that native pigs require the same amino acid balance as improved animals. The main difference in protein utilization reflects the tendency of criollo pigs to accumulate more fatty tissue than improved breeds selected for lean meat production. There have been no published studies defining clearly the nutritional requirements of criollo pigs.

Productive comparisons between commercial and family production have to be made, taking into consideration the investment, management, and nutritional conditions prevalent in the traditional farming systems. It is particularly important to consider that in small farming systems, swine play roles which are not necessarily market-oriented to the extent in commercial systems. Many efforts trying to improve traditional swine production systems have failed because they have not taken into consideration these social and anthropological factors, and have tried to introduce technologies which are not suited either economically or socially to the traditional family systems. One of these examples can be found in the final report of the Cacaotal Project in the Atlantic Coast of Colombia (CIAT, 1975). Closing the program, the report indicates "the farmers' lack of knowledge of nutritional principles has caused them to refuse to buy protein supplements for their pigs." Swine are normally fed leftover products, and cash investments are limited. Furthermore, in a situation where small farmers themselves have a very low protein diet, it would be totally unrealistic to feed pigs rations with 16 to 18% protein levels.

Low production and productivity are consistent characteristics of such systems, and economic studies using traditional economic tools have shown this type of system to be wasteful and unprofitable due to high mortality rates, poor feed conversion, low reproductive rates, and poor-quality final products. These studies have shown substantial losses for the producer. However, in spite of these "findings," small farmers still raise pigs and are apparently satisfied with the results. It is clear that pigs play an important socioeconomic role on small farms, and the apparent contradiction between poor economic performance and the prevalence of swine on small farms appears to be due to inappropriate tools for economic analysis or a lack of social and anthropological understanding of the role of swine in small farming systems.

Similar examples as the one presented for swine can be easily drawn for poultry and family sheep production. Small commercial operations or farmers moving from household to commercial operations might have some sources of technological know-how already available.

An inventory of technologies and an evaluation of its impact is needed especially in the case of household animal agriculture.

THE CHALLENGE

Animal agriculture has faced over the last decades not only lack of attention, indifference, and neglect, but an outright negative bias from national and international policymakers, scientists, and politicians. This situation is reflected in the very limited number of programs or projects promoting livestock development, and the limited amount invested in credit, research, extension, or marketing in Latin America.

The challenge that lies ahead is to reverse this situation, and it requires a very clearly defined strategy in order to demonstrate, beyond any doubt, that those investments in small livestock enterprises and household animal agriculture will undoubtedly bring economic and social improvements at the family, regional, and national levels.

As shown in the preceding chapters, there is a lack of solid information on the economic structure of small farming and especially on the role of animal agriculture. Also, lack of perspective on the biological and socioeconomic impact of "appropriate" technology, or even the availability of technologies suited to small animal farming, requires an inventory and/or survey, matching small farm livestock outputs with adequate technologies, and assessing its potential impact in social, biological, and economic terms.

However, any meaningful effort towards recognition of the importance of animal agriculture requires at least an initial support from international and national agencies. This can be carried out in the following way:

(a) Setting up permanent committees or special boards devoted to answer continually questions presented with regard to animal agriculture, by policy and government decision makers on a wide variety of issues, but with a unified point of view.

(b) Organize a rapid, efficient, and low-cost survey/analysis of the rural household economies throughout Latin America, in which agricultural and nonagricultural sources of income and family support should be accounted. The survey/analysis should cover several settings: from the high Andes pastoralists, to mixed farming, to dual-purpose cattle production, to lowland goat and cattle pastoralists. Such activity, if properly planned and executed, should provide the kind of solid information required for government and policymakers, and help them define the proper equilibrium of productive factors and its future support by agencies' development programs.

(c) Organize a survey of demand and supply of technologies for market-oriented as well as small and household animal agriculture. Particular emphasis should be placed on the potential effects of technologies, required investments, and a cost/benefit analysis of technologies applied. Finally, research policies and priorities should be defined.

(d) Based on the results of (b) and (c), a set of guidelines to help international, national, and local agencies to: (1) understand the social and economic role of animal agriculture, (2) assess its impact in agricultural development programs, (3) evaluate the resources required, (4) set macroeconomic and sector policies that will promote successful animal agriculture, and (5) determine expected benefits at family regional or national level.

REFERENCES

Acharya, R.M. 1987. Breed of goats and research programmes for their improvement in India. *Proc. IV International Conference on Goats.* Brasil.

Alderson, A., A. Naranjo, D.D. Kress, P.J. Burfening, R.L. Blackwell, and O.E. Bradford. 1982. Sheep: comparison of Rambuillet, Corriedale, American Romney, Marsh, British Romney Marsh with native criollo in Colombia. *Goat and Sheep Res.* 2:30-47.

Blond, R.C. (ed.). 1983. *Partners in Research.* A five year report on the Small Ruminant CRSP. University of California, Davis. USAID.

Cabeza, M., J. Buitrago, and A. Owen. 1977. Rendimiento y comportamiento de cerdos criollos Zungo vs Duroc Jersey. VI Reunion ALPA. La Habana, Cuba.

Calle, R. 1982. *Producción y Mejoramiento de la Alpaca.* Banco Agrario del Perú.

CATIE. 1981. *Situación de la producción caprina en Centro América y República Dominicana.* Proyecto Sistemas de Producción para Pequeñas Fincas. CATIE. Turrialba, Costa Rica.

Chauca, L., J. Saravia, and J. Muscari. 1984. Mejoramiento por selección del cuy o cobayo Peruano. En *Informe Anual* EEA, La Molina.

CIAT. 1972. Sistemas de producción de porcinos en América Latina. Centro Internacional de Agricultura Tropical. Seminario Setiembre 18-21, 1972. Cali, Colombia.

Cruz, E.N.M. 1983. Potential of integrated farming system in Asia with particular emphasis on the use of fresh manure from pigs, chickens and goats for fish ponds. *Proc. 5th Wld. Conf. Anim. Tokio, Agosto 14-19 1982.* 1:202-293.

Cunningham. E.P. 1982. Animal breeding under changing economic circumstances. *Proc. World Congress on Sheep and Cattle Breeding.* New Zealand: The Dunmore Press.

Devendra, C. 1981. Meat production from goats in developing countries. In *Intensive Animal Production in Developing Countries.* British Society of Animal Production. Occasional Publication No. 4.

_______. 1985. Prolific breeds of goats. In *Genetics of Reproduction in Sheep,* edited by Land and Robinson. Butterworth, London.

Dillard, A., R. Vaccaro, J. Lozano, and O. Robison. 1972. Phenotypic and genetic parameters for growth in guinea pigs. *J. Anim. Sci.* 34:193-195.

Esuebio, J.A., B.I. Radino, and E.C. Eusebio. 1976. *Recycling System in Integrated Plant and Animal Farming.* Nat. Sci. Develop. Board. Univ. Philipp., Tech. Bull. No. 2.

FAO. 1981. *Energía Animal en la Agricultura en Africa y Asia.* Consulta de Expertos de la FAO. Estudio FAO Producción y Sanidad Animal No. 42.

_______. 1983. *Integrating Crops and livestock in West Africa.* FAO Animal Production and Health Paper No. 41.

Fetuga, B.L., O.M. Babatunde, and V.A. Oyenuga. 1976. Performance of the indigenous pig of Nigeria under intensive management conditions. *Niger J. Anim. Proc.* 4:140-161.

Fitzhugh, H.A., and G.E. Bradford, eds. 1983. *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics.* A Winrock International Study published by West View Press.

Flórez, A., A. Carrasco, N. Gutiérrez, and O. Carhuamaca. 1986. *Desempeño Biológico-Económico de la Asociación Rye Grass-Trébol para Engorde de Ovinos en la Sierra del Perú.* INIPA-Small Ruminant CRSP. Reporte Técnico No. 82.

Gomez-Brenes, R.A., R. Jarquin, J.M. Gonzales, and R. Bressani. 1974. Comparación del cerdo criollo y Duroc Jersey en cuanto a crecimiento y utilización del alimento. *Turrialba* 24:29-34.

_______. 1974. Crecimiento, utilización del alimento y proteínas sericas del cerdo criollo y del Duroc. Resumen IV Reunion ALPA, Guadalajara, Mexico. *Memorias ALPA* 9:35-36.

Gomez-Brenes, R.A., R. Jarquin, C.A. Acevedo, J.M. Gonzalez, and R. Bressani. 1975. Estudios sobre necesidades nutricionales del cerdo criollo: Proteínas. V Reunion ALPA. Maracay, Venezuela.

Gonzalez-Stagnaro, C. (ed.). 1979. Producción caprina en medios difíciles de América [illegible].a. VII Reunión de la Asoc. Latinoamericana de Producción Animal. Panama. Mimeo.

_______. 1979. *Eficiencia Reproductiva y Productiva de Ovejas West African en Explotaciones Comerciales Semi-intensivas en Una Zona Semi-arida de Venezuela.* Universidad del Zulia, Instituto de Investigaciones Agronómicas. Facultad de Agronomía.

_______. 1985. *Crianza y Producción de las Ovejas Tropicales.* Mesa Redonda de Coordinación y Apoyo a los Programas Ovinos en los Paises de la Zona Andina. Oficina Regional FAO, Quito, Ecuador.

Jaramillo, M., J. De Boer, A. Flórez, F. Bryant, and L.C. Fierro. 1985. *Economic Analysis of Range and Forage Management Strategies for Increasing Small Ruminant Productivity in the Peruvian Andes.* Winrock International Research Report. Technical Article T-9-433.

Jimenez, L., and D. Hobbs. 1985. *Social Organization of Alpaca Production in Perú: A Case of Study.* Small Ruminant CRSP. Technical Report Series. No. 72.

Kleeman, G., M.F. Guerrero, G. Gomez, J. Maner, J. Buitrago, and A. Owen. 1975. Comparación de rendimientos de razas de cerdos (Zungo) colombianos, Duroc y sus cruces en zonas tropicales. V Reunion ALPA. Maracay, Venezuela.

Land, R.B., and D.W. Robinson. (eds.). 1985. *Genetics of Reproduction in Sheep.* Butterworth, London.

Lencinas, M., R. Alencastre, B. Quijandria, and R. Blackwell. 1984. Reporte preliminar sobre parametros biológicos en ovinos criollos. *Resúmenes VII Reunión Científica Asociación Peruana de Producción Animal.* Lima, Perú.

Mason, I.L. (ed.). 1980. *Ovinos Prolíficos Tropicales.* Estudio FAO de Producción y Sanidad Animal No. 17.

Maule, J.P. 1977. Barbados Black Belly Sheep. *World Animal Review* 24:19-23.

McDowell, R.E., and P.E. Hildebrand. 1980. *Integrated Crop and Animal Production: Making the Most of Resources Available to Small Farms in Developing Countries.* A Bellagio Conference. The Rockefeller Foundation. Working Papers.

Murillo, O., and Navarro, L. 1986. *Validación de Prototipos de Leche en la Zona Atlántica de Costa Rica.* CATIE. Turrialba, Costa Rica. Serie Tecnica: Informe Tecnico 90.

Pearson, Lucia. 1970. The role of livestock in developing economics. *Advancement of Science* (March): 289-297.

Perevolotsky, A. 1984. Goat Herding in Piura-Perú: The enviromental context and the human factor. Thesis Ph.D. in Ecology. University of California, Davis.

Quijandria, B. 1981. Swine production systems in Central America: Limiting factors, prospects and research requirements. In *Intensive Animal Production in Developing Countries*. British Soc. of Anim. Prod. Occasional Publication No. 4.

_______. 1984. Goat research project in Northern Perú. In *Patterns in Research*, edited by R.D. Blond. A five year report of the Small Ruminant Collaborative Support Program. University of California, Davis.

_______. 1986. Animal production systems in Central America. In *With Our Own Hands*. International Development Research Centre (IDRC) 246s.

_______. 1987. *Caracterización de las Explotaciones Pecuarias dentro del Marco de la Encuesta Nacional de Hogares Rurales*. I Publicacion sobre Analisis y Difusion de Resultados de la Encuesta Nacional de Hogares Rurales. GAPA-PADI. Ministerio de Agricultura. Perú. En Prensa.

_______. 1987. *Livestock Evaluation and Assessment for the ATT Project*. USAID. Perú.

Quijandria, B., C. Espinosa, V. Agreda, R. Valer, and A. Garcia. 1987. Sistemas de producción y economía campesina: Caracterización de estrategias productivas. II Seminario Permanente de Investigacion Agraria. Ayacucho 16-20 Mayo, Perú.

Quijandria, B., M. Zaldivar, and O. Robison. 1983. Selection in guinea pigs: II Direct response for litter size and body weight. *J. Anim. Sci.* 56:820-828.

Sumar, J. 1985. Reproductive physiology in South American camelids. In *Genetics of Reproduction in Sheep*, edited by R.B. Land and D.W. Robinson. Butterworth, London.

Timon, V.M., and J.P. Hanraham. 1986. *Small Ruminant Production in the Developing Countries*. FAO Animal Production and Health Paper No. 58.

Vaccaro, R., E. Dillard, and J. Lozano. 1968. Crecimiento del cuy del nacimiento al destete. *Memoria de la Asoc. Latinoamericana de Producción Animal* 3:115-126.

Valer, R. 1985. *Evaluación Económica Ex-ante de Modelos Mejorados de Producción Caprina*. Programa Caprinos del Norte. INIPA-IDRC. Reporte Técnico.

Velasco, J., M. Condorena, D.D. Kress, P.J. Burfening, and R. Blackwell. 1981. Breed characteristics, color and weight inheritance in alpaca. *J. Anim. Sci.* 54:156. (Abstract.)

Villalobos, R., J.C. Schulze, O. Reinstein, and N. Maynard. 1985. *Proyecto de Fortalecimiento de los Servicios de Extension Agropecuaria para las Comunidades de la Sierra del Perú*. International Fund for Agricultural Development (IFAD). Rome, Italy.

Villarroel, J., and M. Gamarra. 1978. El Ovino Raza Junin. SAIS "Tupac Amaru" Limitada No. 1. Pachacayo, Perú.

Winrock International. 1976. The role of sheep and goats in agricultural development. *Proceedings of a Workshop*. Winrock International and USAID.

ROLE OF ANIMAL AGRICULTURE IN IMPROVING ENVIRONMENTAL QUALITY

Dr. Arturo Florez
Co-Director, Livestock Research
Instituto Nacional de Investigación Agraria y Agropecuaria, Perú

THE PROBLEM

As the earth's population increases beyond five billion and economic expectations rise, more and more of the earth's life-supporting systems become subject to exploitation despite long-term ecological and economic costs. Badly managed exploitation of ecosystems has led to increasing degradation, reducing many to an unproductive state. The total area of destroyed or degraded soils, which were once biologically productive, is estimated at 20 million km^2, which is more than the entire arable area used for agricultural purposes at present. Some 5 to 7 million hectares of land are lost to agriculture each year through erosion, salinization, settlement building, etc. The destruction of soils by misguided human activity is usually irreversible.

The earth's arid and semiarid ecosystems are among those most seriously affected by man's exploitation, and in many parts of the world they are losing their capacity to support human populations that depend on them for survival.

Man-made deserts account for one-sixth of the total area of the world's deserts, which now cover 43% of the earth's land area. Particular attention is given to the desertization process because it is an extreme example of aridization, a process threatening the whole world.

The destruction and degradation of tropical forest ecosystems is accelerating at an alarming rate. If present trends continue most of the existing forests of the tropics will be destroyed by the end of the century, an environmental and economic loss of great significance, especially to the developing countries in which such forests are found. The earth's mountain ecosystems are particularly susceptible to poor land management practices aggravated by increasing population pressure.

Thus, nature's basic resources, such as soils, water, and genes and their inherent diversity, which are fundamental to man's future, are being continually eroded. If man is to have any long-term future he must learn to manage these resources according to the principles of biological systems.

ACTUAL VIEW

The protein food deficit is already beyond the normal productivity of areas now dedicated to livestock production. Latin America is probably the region that can contribute significantly to the increased production of animal protein for human nutrition.

In the large areas of America, Australia, Africa, and Asia, located between the Tropics of Cancer and Capricorn little effort has been made by livestock producers and technicians to improve productivity until recently. Even with access to modern technology, some aspects cannot be used to get better results because of the lack of necessary equipment and money. In these large intertropical regions today, a good part of the livestock give very low production, compared with production in the temperate regions of both hemispheres.

In tropical areas, there are many vital, complex factors that must be taken into consideration, such as the climate and soil that influence the organisms that live in it. Many of the livestock species that are raised have low genetic potential. Another factor is rudimentary range and pasture management systems in which livestock do not receive any special attention. This situation sharply contrasts with the progress in livestock raising achieved in the temperate zones. Considering the need for improvements in American countries, the concepts that follow are strictly directed to the actualization of modern technology that can increase livestock production.

According to the Food and Agriculture Organization of the United Nations (FAO), there exists in the Americas a huge number of livestock: 400 million bovines, 200 million sheep and goats; 165 million pigs, and 50 million horses, donkeys, and mules.

With respect to beef cattle, the stock of the Americas represents one-third of the world production, or about 1,200 million, which is about the same number as in Asia, but more than in Africa, Europe, and Oceania combined. The distribution is: North America 170 million, Central America and the Caribbean 20 million, and South America 210 million. If we relate the animal population of these areas with the climate conditions, there is a big difference. In temperate zones of the eastern and western hemispheres there are approximately 200 million cattle similar to numbers in the tropical and subtropical zones.

CAUSES OF LOW YIELD OF LIVESTOCK IN LATIN AMERICA

The low yield of the Latin America livestock production is attributed to several factors. Among these are:

- Ecological: climatic variations, lack of minerals in the soils, and sanitary problems
- Infrastructural problems: lack of transportation, cold storage houses, and ports, leaving large areas almost isolated
- Low management levels: systems of exploitation and transformation are rudimentary and are in need of financial and technical inputs
- Genetics: limited genetic potential in most indigenous livestock, like the "criollo cattle" and "criollo sheep"

ANIMAL AGRICULTURE IN THE HIGHLANDS OF PERU

In mid-1987 Perú had a population of approximately 20.7 million, many of whom have migrated to urban areas in recent years. Today Perú's cities hold more population than do its rural areas.

For the purpose of this discussion, the highlands (Sierra) are divided in three zones: North, Central, and South.

Northern Highlands

In the northern highlands which have a population density of 25 inhabitants per km^2, 83% of the population is rural. Only 5% of its land is cultivated, mostly with maize, pastures, wheat, barley, potatoes, and beans. The main agricultural areas are Cajamarca and La Libertad, because they are located in an area of the Andes that is not as high as the central and southern highlands.

Rangelands cover almost 50% of the area, divided in equal parts between seasonal and permanent. Cajamarca is a milk region important to Lima and Arequipa and most of its pasture is dedicated to the approximately 110,000 milk cows of the region.

Central Highlands

Sixty-five percent of the population of the central highlands is rural. Population density is 19 inhabitants per km^2 and 6% of the total area is cultivable. Only 4% of the area is cultivated using rotational crops, thus allowing the land to rest for 3 to 5 years between harvests. Agriculture is diversified and includes potatoes, barley, maize, wheat, alfalfa, and indigenous crops like "ollucos," "quinua," "kiwicha," "oca," and pastures. There are also trees like "eucaliptos" that cover almost 2,000 ha. Native rangelands cover 65% of the total area and more than 90% of these are permanent. With the predominance of rangelands, livestock raising, particularly sheep raising, is one of the principal activities of the region.

Southern Highlands

The southern highlands have around 11 inhabitants per km^2 with 6% classified as rural. This region is also mountainous and the cultivable area is only 3%, of which 70% is worked and the rest is fallow between crop rotations. Among the most important crops are potatoes, maize, barley, alfalfa, wheat, "quinua," pastures, and "habas." The native range covers 62% of the total area, with 95% classified as permanent. As in the central highlands, sheep are the most important animal followed by cattle. A major difference from the central highlands is that camelids, especially alpacas, are equal in importance to cattle.

Climatic Conditions

Because of its latitude, Perú should have hot and rainy weather (tropical humid). However, due to the Andean Cordillera (mountains), the "anticiclón" of the South Pacific, the Peruvian marine current (Humboldt), and the equator marine current "Del Niño," we have different climatic conditions. Some ecologists affirmed around 80% of the world climates can be experienced in Perú.

The highlands have strong rains varying from 500 mm in the south to 750 mm in the north. The rainy season is from December to March, but the wettest quarter accumulates only 40 to 60% of the annual rains; this increases to 60 to 70% in the arid south. The driest quarter registers from 10 to 20 mm of rain, excepting the west part of Junin and Pasco where the rains of the three driest months are 30 to 40 mm on average. The highlands, because of altitude, is a cold zone with snow in the highest part, 5,000 m. Rarely is there snow below 3,200 m. At 4,000 m, snow is more frequent but disappears as soon as the sun rises. During the dry season with an open sky and an intense night radiation, the night frosts are very common, though they also happen during the humid season.

The Highlands -- Region of Native Rangelands

Its altitude is between 3,800 and 4,600 m. It is formed by a small to medium vegetation which grows in the rainy season. Most of the grasses are perennial, growing to 1 m in the tallest species as *Festuca dolichophylla*. Shrubs are very few. During the dry season most delicate herbs disappear, surviving only by a vegetation formed principally by grasses.

The Puna, Rangelands Area

The name "Puna" is generally given to the high region not good for agriculture. The native range starts at 3,500 m in some cases but more commonly at 3,800 m ending at the high cordillera. The characteristics of this range are the strong types of perennial grasses, especially the ones of the genera *Festuca* and *Calamagrostis* of approximately 1 m in height influenced by the topography, soil, and weather. All these species are called "ichu" by the "campesinos." These areas show different kinds of soils according to the management given to the range. Range sites are covered from 10 to 100%.

The grasses are variable in number of species, with characteristics of a single stem lightly ramified and at the same time underground, so that only the leaves are visible. That is the case for rosette plants such as *Calandrina acaulis*, *Linbum bullatum*, species of *Nototriche hypochoeris* and others. In the high areas where soil has great humidity, there are the so-called "bofedales," distinguished principally by species like *Distichia muscoides*, that belong to the *juncaceae* family. It is a short plant with stems in the form of a needle, ending in a cluster with stems close to each other that forms a kind of cushion which resist the weight of the animals, especially the alpaca for which it is the principal food.

The Jalca Rangeland Area

The area that is located above the limit of agriculture in the northern highlands is known as "Jalca." The Jalca is a large portion of land, wide in some places and narrow in others. It is a zone similar to the Puna of central and southern Perú, but has a lower elevation. The weather is humid, the sky is cloudy, and the fogs produce a cold effect all year round. The Andes are of a lower altitude starting at 8°30' longitude. Going to the north, the increasing latitude affects the type of vegetation which grows there. Most of the Jalca is under 4,000 m elevation.

The flora, especially in the high mountains, has some species similar to the Puna such as *Nototriche*, *Azorella*, and *Werneria*. Rosette plants are not common in this area. The average vegetation of the Jalca is composed of grasses, largely free of shrubs. The dominance of grasses is more than in the Puna, and that is the reason why cattle production is larger in this area.

The rangelands have an area of 21,315,000 ha in Perú. However, according to land capabilities only 12,812,000 ha are suitable for grazing. That means there are 8,503,000 ha that should be considered as protection areas. Actually, all the 21,000,000 ha of rangelands are grazed, with the results of overgrazing, erosion, and aridization.

Livestock Population and Grazing Capacity

The most recent census of the Agricultural Ministry of Perú indicates a population of 4,021,600 cattle, 15,258,000 sheep, 2,506,500 alpacas, 1,361,050 llamas, 2,029,900 goats, and 1,303,450 horses. This population has been transformed to sheep units, with respect to the three main animal grazing species: cattle, sheep, and alpaca. The procedure was to multiply the number of head of each species by the factor 0.8 to obtain the total adult population and then transform it to sheep units. Taking as reference the area of native rangelands in hectares, the actual stocking rate has been calculated in sheep units/ha/year. On the other hand, the optimum average stocking rate for the natural range is considered as 0.5 sheep unit/ha/year. There is an excess of animals per unit of area, as the general average is 1.7 sheep units/ha/year, which leads to overgrazing.

Land Tenure in the Highland Region

According to the Second National Livestock Census which was taken in 1972, there are 1,083,066 livestock production units; 56.99% has extensions that varied from 0 to 2 ha and the 91.70% are units that range from 0 to 10 ha. This big percentage of livestock production units covers only the 2.09% of the area with native range, which indicates the serious problem of "minifundio" that exists in the highlands, and the number of small livestock production units, of less than 10 ha.

On the other hand, livestock units in holdings larger than 2,500 ha represent 0.12% of the total units, and use 68.35% of the rangelands. Among this group we have the "Comunidades," Agrarian Cooperatives of Production (CAPs), and Agrarian Societies of Social Interest (SAIS).

Before the Agrarian Reform in Perú, 22 million hectares of native range were divided into 8% property of the large farms, 23% property of the medium farms, 11% to small livestock producers, and 58% were in the hands of "Comunidades Campesinas."

After the Agrarian Reform, the large farms were totally affected and the lands became what we know now as Agrarian Societies of Social Interest. A portion of the medium farms were also affected forming what is now the Agrarian Cooperatives of Production. The lands of the "Comunidades Campesinas" were not affected. In this way, after the Agrarian Reform, in the highlands of Perú, the land tenure is in the hands of the "Comunidades Campesinas" (58.2%), SAIS and CAPs (34.6%), and medium and small landholders (2.8%). With a lack of technical assistance from the government to the "Comunidades," the resources, especially of the rangelands, are poorly managed and, as a consequence, produce livestock poorly in comparison with the large farms.

Multiple use of land in the "Campesino Communities"

For two reasons, any economic theory that would try to explain the behavior of the peasant family of the highlands has to include the risk factor as a principal element. First, because almost all economic activities of the "campesino" in the highlands are risky; and second, because the peasant families are poor. It is understandable that a poor family would have an aversion to risk because they are too poor to gamble with their income. An important loss of income will mean economic disaster. They prefer a little less income to the possibility of taking a risk and suffering a big loss. The way to minimize the risk is by a combination of activities.

The main activities for the "campesino" are agriculture, livestock, and "artesanía." Agriculture in the highlands is tremendously risky because if they do not have irrigation they depend strictly on the rains. The absence of rains, its excess, or its untimely advent produces drought, flooding, and landslides, respectively. At certain altitudes, frost and hailstorms are climatic factors that also affect production. To these climatic problems are added the ones caused by diseases and pests.

Livestock has important risks. Diseases, pests, and bloat are some of the risky elements. Besides, there is the problem of cattle stealing that is so common and serious in the highlands.

Diversification does not refer only to different activities, but includes diversification even in the same activity. For example, the peasants have a diversified agriculture. Each family cultivates different products in different plots, so the questions are: Why don't they specialize in some crops? Why the fragmentation of plots? Certainly, a diversification of crops is a means for the "campesino family" to obtain yields from plots in different ecological levels. In this way, they have access to different resources and more possibilities of production. The negative effects of the climate and pests are not the same in all the ecological levels and the probability of having a bad harvest in all the plots is low.

Even in the same ecological zone, the "campesino" has many plots as a way to minimize risks due to the existence of microclimates. The frost, for example, affects only part of an area and more in the flatlands than in the slopes. Besides, the "campesino" does not use all of the plots for crops in a given year. They have other plots for fallow. This behavior of the "campesino" has been the principal cause of the destruction of natural resources, mainly the native rangelands.

In the highland, it is very common to observe that the slopes are cultivated for agriculture without hope. This destroys the native range, which is the product of the plant succession, in a short time, with the end result of erosion and landslides. The highlands is the only region in Perú where the actual use of the land, at 3.9%, is higher than the optimum recommended use.

Burning Rangelands

In the highlands of Perú, it is common practice to burn the range sites, especially those on the slopes. The reason is to eliminate tall grasses, that neither sheep nor alpaca eat. Fire practiced each year changes the plant community, increases the bare areas, and eventually produces serious erosion problems. Research studies on this matter indicate that burning is not suitable practice for this kind of vegetation and there are other ways to use tall grasses, for example, through the common grazing of cattle or llama that like to eat tall grasses.

Overgrazing in the Highlands

Because of the excessive number of domestic livestock that graze the rangelands of the highlands of Perú, a serious problem of overgrazing has been taking place during the last 50 years. This became worse in the last 5 years because the rangelands of the big cooperatives are being given to the communities. As we know, the net effect of heavy grazing is to bring about a change from a range site in which some or all of the plant species fu 'sh food for the herbivores, to a new community in which the plants are relatively unpalatable, unavailable owing to growth form (spiny or prostrate), or green for only a brief period. Also, in some overgrazed areas, trampling is so excessive that even the actual community of plants is destroyed. As a general result, reduction in the amount of manure and plant litter, compaction of soil, and increased erosion are other measurable changes in the ecosystem as the vegetation is altered.

Seventy percent of the rangelands of Perú are actually poor today.

MAIN CAUSES OF UNDERPRODUCTION IN THE HIGHLANDS ECOSYSTEMS

The main reasons for the malfunctioning of biological animal production in the highland ecosystem of Perú are the following:

- Gradual soil impoverishment of mineral salts (essentially phosphorus and nitrogen) during thousand of years of cropping and grazing.

- Malfunctions affecting the water cycle: degradation of hydrodynamic conditions of surface and subsoils, present inefficiency of small-scale water management systems that worked in the past.

- Wind and water erosion of living fraction (arable) of soil, due to cropping and grazing practices and long period of time when the soil is left bare.

- Human pressures on Peruvian high mountain ecosystem are increasing nearly everywhere. The "Sierra of Perú" is unusually sensitive to quite small disturbances and the consequences are often irreversible.

- The degree of exploitation and management that varies from place to place and between animal species, together with the range of socioeconomic and cultural inputs and outputs, that in the majority of producers in the highlands, such as the "Campesino Communities," marginal self-sufficient groups tending toward a cash economy, but remaining marginal. Socioeconomic practices and problems differ from sheep and alpaca herding communities of the same geographical region.

Research Accomplishments

In the last 25 years there was no cohesive approach to confronting the severe constraints upon animal productivity in the harsh and isolated environment of the highlands of Perú. Only scattered efforts were made. In 1960, the North Carolina State University established the Forage Research National Program and the Livestock Research National Program in Perú, both of which made some interesting accomplishments in the field of range management and pasture. Later on, several national institutions like the National Agrarian University at La Molina, the Institute for Tropical High Altitude Research (IVITA), Lima, and other universities in the highlands carried out many experiments mainly in relation to range, pasture, animal nutrition, and animal health. Since 1981, the Small Ruminant Collaborative Research Support Program that involves USAID, U.S. universities, and host country agencies as equal partners, focuses major research in the improvement of sheep and alpaca productivity in the Andean peasant communities. The research is conducted in collaboration with the Instituto Nacional de Investigación Agraria y Agropecuaria (INIAA) and several universities including La Molina, IVITA, Cusco, Puno, Arequipa, and Lambayeque.

On the other hand, in the field of extension and technological transfer, there is very little work done. One example is the New Zealand Mission that, since 1974, in cooperation with Peruvian Agricultural Agencies, established patches of permanent improved pasture (5,000 ha) in the high plains ("altiplano") of Puno.

The research that has been and is being done, does not constitute an integrated research plan that covers all the factors that affect animal production in the highland environment.

The research done in the last 20 years must be published; presently only an estimated 10% is published. From these data, very little was transformed into technological packages for transfers to farmers.

If we consider the donor policy to help in livestock production in Perú, a change will be needed as the present focus is on the lowlands. The International Center for Tropical Agriculture (CIAT), the USAID/North Carolina State University Project, the International Development Research Centre (IDRC), and other European countries are working on lowland technologies while international technical assistance to the highlands is very limited. This same problem of technical assistance is repeated in the Andean countries of Ecuador, Bolivia, and Chile.

Donor assistance should give more help to the Andean ecosystem for the following reasons:

- These areas of extreme altitude exert a major influence on the climates and hydrology of the east part of the continent: The Amazon area.

- If we find alternative practices to reduce the stocking rate in the rangelands, these will improve the soil cover and reduce the erosion. In this way the environmental quality will be better.

- The multiple use of the rangelands depending on their ecological condition should be stressed, maintaining the steep slopes as protection areas for watersheds. This will improve the hydrological cycle and environmental quality.

- In areas with good potential for grazing, a complementary system of land use should be taken into consideration. This is the rational use of rangelands with good management: improvement of overgrazed lands on the flat or slide slopes; use of pasture under irrigation to raise the stocking rate between 1,000 and 2,000%; and forage conservation, especially silage for use in the critical seasons.

If we are able to do this, livestock agriculture (or raising) will increase in productivity, creating better living conditions for the farmers, especially for the peasant communities.

ANIMAL AGRICULTURE: DEVELOPMENT PRIORITIES TOWARD THE YEAR 2000, DONOR EXPERIENCE SINCE 1960

Peter J. Brumby
World Bank

ABSTRACT

In the last two decades the developing countries have greatly increased their net imports of meat and dairy products, thereby losing their former role as important net exporters of livestock products. Whatever production increases have occurred have been based mainly on increases in livestock numbers, not animal productivity; the resulting pressure on limited land resources is the source of many environmental problems. Livestock projects generally, and particularly those in Africa, have not enjoyed a good reputation in economic gradings; their poor performance has been compounded by our inadequate understanding of the role of livestock in economic development.

The reasons for this situation are frequently associated with difficulties in the transfer of technology, a lack of local research, insufficient institutional support, instability in economic policy, inadequate producer incentives, and deficiencies in local project management and financial support. Greater flexibility in donor support, lengthening commitment periods, strengthening research facilities and national animal health systems, and modifying the policy environment are the general recommendations that commonly emerge from reviews of the livestock projects of the major donors. Additional stimuli can be found in:

- emphasizing the role of livestock in economic growth
- encouraging greater innovation in livestock technology
- enhancing complementarities in food aid, technical assistance, and financial investment
- facilitating international trade opportunities

INTRODUCTION

Animal agriculture in most developing countries has a modest record. In the last two decades:

- Net livestock exports from developing countries have declined in spite of expanded world markets.
- The reduced availability of livestock products in their domestic markets has increased prices.
- Changes in livestock productivity have been small, thus increases in stock numbers still account for most of the change in output.

- The resulting grazing pressure on limited land resources is creating greater environmental problems.

- There has been a reduction in donor support to livestock development.

Many of the factors which contribute to this disappointing scenario arise outside of the agricultural sector. Transportation difficulties, inadequate market infrastructure, high capital and borrowing costs, an absence of consumer goods, poor price incentives, and the unavailability of farm inputs are common impediments. But important as these problems are, the central reason for the disappointing performance of the livestock sector lies in our failure to improve the technology of animal production in developing countries. A paradox has resulted: there is an oversupply of meat and milk in the industrialized countries and a growing export trade from the former to the latter at prices that discourage local production.

The arguments used to justify greater livestock production in developing countries are usually based on the need to meet projected deficits in this production of meat, milk, and eggs. This approach is clear and pragmatic, but a more important reason for emphasizing the importance of livestock development programs rests on the contribution they make to total farm production and to economic growth.

The reasons for emphasizing the economic impact of livestock development start with the observation that the ultimate beneficiaries of the development effort are the consumers, as the impact of improved technology and productivity in livestock and agricultural production is to lower prices relative to what they otherwise would be. This results in the "paradox of success" of agricultural research, one that leads to many farmers experiencing income losses and leaving the sector, while consumers and the economy gain.

The second observation that underpins the economic importance of livestock is their role as the primary source of cash income for many smallholders; small increases in livestock production quickly increase farm income and the availability of money for fertilizers and other crop enhancing factors. A better diet then results through increases in overall food supplies, lower food costs, and increased employment opportunities. Another economic role of livestock is that of providing linkages to crop production through soil cultivation and fertility needs, and to agroindustrial development through the demand for feed supplies, product processing, and marketing services. Livestock also provide a large and stable labor demand throughout the year, they are an important sources of savings for rural families, and they constitute a highly liquid asset.

It is the contribution to and role of livestock in economic growth that the donors have failed to sell; it is a perspective that must be stressed if investments in livestock production are to be increased.

A useful way in which to focus this discussion of donor experience and inadequate livestock production is to highlight the themes that recur in the observations of various donors when reviewing their livestock portfolios. These observations include:

- the impact of current trends in international trade

- the role of the policy framework within which all development activities occur

- the importance of farmer organizations and the privatization of support services
- the synergism of financial investment, technical assistance, and food aid
- the need for the integration of the production of crops and livestock within sustainable farming systems
- the constraints imposed by the lack of appropriate technology

TRADE TRENDS

World production of meat, milk, and eggs now amounts to about 150 million, 500 million, and 35 million tons, respectively. The industrial countries have about one-quarter of the world's livestock and human population but they produce two-thirds of the world's meat and three-quarters of the world's milk. The resulting difference in the availability of meat and milk per person in the developed and developing countries is of the order of 10 to 1.

In the years since 1970 the developing countries have greatly increased their imports of meat and dairy products, losing their former role as important exporters of livestock products. Imports of meat, milk, and eggs to many developing countries are now expanding by about 10% a year in spite of the livestock potential available to so many of these countries. Their production of poultry and pigs has grown appreciably faster than of beef and milk but, in many cases, this production has been based in imported feedgrains, thereby discounting its impact on the agricultural sector.

In the last decade the European Economic Community (EEC) emerged as the world's largest producer and exporter of meat and milk, a result of strong support to domestic market prices through intervention purchases. Their export disposal of the present surpluses requires subsidies averaging about 50% of regular domestic prices. These subsidized exports severely disrupt normal commercial trade and they distort production incentives in countries that import subsidized meat and milk. The major determinant of future international prices for meat and milk will be the policies of those developed countries who are currently heavily subsidizing and protecting their agriculture, thereby depressing price incentives and production in the rest of the world. Studies

Table 1. Value of meat and milk imports and exports (US$000)

	Meat		Milk	
	1973	1983	1973	1983
From LDCs to LDCs	386,313	1,109,807	41,650	126,547
From DCs to DCs	548,724	874,408	874,724	3,298,783
From LDCs to DCs	2,046,965	1,853,021	15,317	37,630
From DCs to LDCs	8,322,356	14,467,436	2,322,356	6,947,656

by the World Bank and the Food and Agriculture Organization of the United Nations (FAO) indicate that removal of these subsidies, and of trade barriers to livestock products, would have a very large effect on international trade in livestock products.

THE POLICY FRAMEWORK

Inappropriate economic and fiscal policies carry much of the blame for the relative failure of livestock production in developing countries. Major problems are encountered in policies at three levels: the overall economic environment, particularly the exchange rate; the livestock subsector, particularly price controls; and at the project and farm level where the availability of local funds, and of production inputs, is the usual problem. Without a policy environment sufficient to support the objectives proposed at the national, sector, and farm level, useful livestock development initiatives invariably run into difficulty, but identifying a real problem is one thing, overcoming it is another.

Current development jargon now centers on the importance of appropriate policies, strategies, and priorities. Meanwhile, the hard political realities or urban living costs, budgets based on agricultural taxes, traditional land use rights, of unequal cultural privilege, and debate over the necessary degree of government intervention in the commerce of the nation remain. Simply stated, the basic conditions needed to induce innovation and technological change in the livestock industries of many countries are not in place; many livestock production practices in everyday use are incompatible with official strategies that proclaim greater production and self-sufficiency, diversification, sustainable land use, increased farm income, and greater national equity. To spend countless years in planning livestock strategies without confronting these traditional production realities is nonsense, as is the pursuit of change in commodity prices when current political policies, based on pri ' bility, make these unacceptable and a solution has to be sought within the framework of continuing constraints.

The imposition of outside "strategies" often produces perverse effects and the opposite to what is intended can result. Distortions in production incentives to farmers, induced by the effect of controlled exchange rates on prices, and by regulation of market channels, are common but new policies suggested by donors are only superior if they achieve the same social and political goals as the old ones at a lower economic cost. New policies imposed by donors are easily nullified and they often prove less efficient than those they seek to replace. One example is the effect of trying to remove export taxes on beef. This approach of trying to increase producer incentives is readily changed by manipulation of the exchange rate, or by increasing slaughter charges and taxes.

In urging recipient countries to establish livestock priorities, and to formulate a long-term strategy to implement these, the need for building flexibility into the planning process is frequently overlooked; circumstances change, often very quickly. Ten years ago who thought Europe would be the dominant exporter of beef and dairy products, who thought India would be an exporter of grain, who thought disposal of surpluses would dominate discussion at international meetings? The very real problem in formal strategic planning is that it locks the participants into rigidities of thought and action from which it is hard to escape. With the great wisdom of hindsight it is not unusual to find the premises on which a strategy has been based were incorrect, or to have changed over time. Flexibility and opportunism are as important as priorities and strategies, balancing these contrasts is the challenge.

DEVOLUTION OF AUTHORITY AND PRIVATIZATION

There is a consensus amongst donor organizations that the role of local organizations, particularly village farmer and pastoral associations, remains a neglected area in livestock development activities and that increased devolution of central authority to farmer institutions is a desirable objective, along with the privatization of the services supporting livestock development.

Two good examples of the success of this approach are found in the village dairy cooperatives that form the basis of India's dairy industry (Annex 1), and in the emerging importance of pastoral associations in the rangeland areas of Africa. The lessons which emerge from these examples of this approach include:

- Long-term collaboration and support to local management is essential, these are not entities which can be created and sustained by itinerant visits and a short-term donor involvement.

- A local revenue base is critical to the sustainability of the local organization.

- Information systems developed within local organizations provide a cost-effective approach to the data collection required for wise planning in the livestock sector.

- Private voluntary institutions are effective in facilitating and supporting village-level action.

The now popular concept of "privatization" of support services to the livestock industry raises two broad questions: what is the essential role for Government in the activities under consideration, and is there really much development potential in changing the present situation.

The initial focus of privatization in the livestock sector is usually the need for veterinary care. In this matter the key role for Government is to ensure the integrity of the services available to stock owners. These include the quantity and quality of the vaccines, pharmaceuticals and professional advice available, and assurance that the public is protected from disease of livestock origin. The activities which cannot be handed to the private sector include the maintenance of these central requirements plus a diagnostic facility and capability in epidemiological studies. The licensing of veterinary professionals is also an essential Government function. With the increasing failure of government-provided health services, it is common to find that farmers make additional payments to secure the services they want, so that *de facto* the public sector officials compete with embryo private services. Thus, private sector development can only take place if Government supports it; the problem then is how to achieve a transformation from the traditional government services. Independent professionals can only operate to the extent that their services are paid for via an adequate volume of business; in many developed countries this problem is handled by the contracting of certain functions, by government, to private veterinarians.

In countries which have an adequate supply of graduate manpower, the assumption is often made that if Government continues to discharge its basic health functions, private services will emerge where farmers are prepared to pay for additional services that they need. Yet this approach begs the question whether developing country farmers can afford both a private veterinary service as well as a government one dealing with epizootics and zoonoses. A pervasive problem is how to control the size of the government service so not to constrain the development of the private service; agreed ground rules with Government on cost recovery, handling of imported drugs, vaccine production standards, and methods of contracting disease control responsibilities to self-employed professionals provide the basic approach.

For countries where trained staff are in short supply, there are several complementary ways in which operating economies in health services can be achieved. The first is through the use of lower-paid paraprofessionals located in villages or who travel with transhumant herders. The second involves the establishment of regular clinical routes and treatment points for the veterinarian as a means to save on transport costs. The third is to use livestock associations and cooperatives as the distribution body for drugs and as the possible employer of the contract veterinarian who may also have a contractual responsibility for undertaking certain tasks for the Government Veterinary Department.

SYNERGISM AND PROBLEMS IN DONOR SUPPORT

There are important complementarities in the types of support that different donors can most readily provide: three major categories include investment funding, food aid, and technical assistance. When these come together in a well-coordinated program the results can be very impressive, as India's dairy operations illustrate. There is large scope for much greater donor collaboration in our respective efforts.

There is also scope for greater awareness by donors of the problems that come with outside assistance. In the research business this outside funding diminishes the need to foster a local political constituency that must exist if sustained local funding is to be provided; it facilitates a distancing of research institutes and their programs from local research needs, thereby fostering the "ivory-tower" syndrome. For all types of projects, it is associated with marked discontinuity in the funding of sequential phases of external support and it opens the door to external leverage regarding the imposition of "policy decisions" that may not be desirable.

LIVESTOCK, CROPS, AND SUSTAINABLE FARMING SYSTEMS

Livestock are often regarded as a destabilizing factor in land use systems; their causal role in this lack of sustainability of land use centers on overgrazing, deforestation, and competition with wildlife. The reality is a little more subtle than this simplistic scenario implies.

Deforestation is usually caused by economic subsidies which enable unsound and uneconomic land use to be profitable while overgrazing is the product of unsatisfactory land tenure policies. The basic cause of land abuse in the poorest countries centers on the very low incomes, savings, and investment of their predominantly rural populations; smallholders and pastoralists can be easily locked into a pattern of declining land productivity and an often destructive exploitation of resources in fragile environments.

To break this cycle of human and land degradation, and to create greater labor absorption in farming areas, larger income streams for smallholder farmers are required. Improvements in livestock productivity are crucial to this change as they quickly result in an increased availability of funds to improve subsistence farming practices. The problem that faces all donors is the extent to which support for economic development in highly stressed areas can be balanced with our concern for environmental protection. There are few success stories to relate in resolving this conflict; a great deal is yet to be learned but at least we know we have to treat the cause and not the symptoms. Increasing the productivity of the semiarid rangeland, and improving land use in densely populated hill areas are two major problems we do not have answers to; enabling people to move out of such areas is a critical part of the solution.

More encouragingly, technology transfer to less difficult conditions shows some success. The establishment of the use of legume pasture within a crop rotation in the mediterranean areas of North Africa and the Middle East, based on Australian experience, is promising, as are the alley farming and fodder bank techniques largely developed in Africa. The white clover-phosphate technology that underpins New Zealand's livestock industry is being adapted to the cooler parts of Latin America; it also provides a useful approach for the development of tropical grasslands. The use of the rumen bacteria, found recently by the Commonwealth Scientific and Industrial Research Organization (CSIRO), that bring about the degradation of the toxin found in the otherwise excellent fodder tree *Leucaena* is spreading quickly. The use of improved animal traction techniques, particularly to effect surface drainage on heavy clay soils and to construct water storage ponds, is making headway. In animal breeding, a recent notable success has been the recognition of the practical value of the "trypanotolerance" trait found in a few breeds of African livestock. Crossbreeding indigenous cattle with imported exotic breeds is widespread but still beset by many unresolved problems associated with milk letdown, as well as biological fitness, and by the genetic and logistical problems involved in maintaining a breeding program that provides subsequent generations of productive crossbred animals. New initiatives in animal nutrition, based on the better utilization of crop residues, and of sugarcane for monogastric animals as well as ruminants, provide a focus for attempts to achieve a better matching of livestock production systems to available feed resources.

Overriding the specifics of these ideas is, however, the observation that livestock programs that have been successful prove to be based on the integration and complementarity of crops, forage, pastures, manure, and animal draft, on efficient linkages in the supply of farming inputs, prices, and markets, and on providing research support and training appropriate to local farming systems. The gap which exists between promise and reality in the performance of livestock in Third World countries continually emphasizes the need for future efforts to develop better technology, particularly so now the biotechnology promises such a useful impact on food and fiber production.

THE PROMISE OF BIOTECHNOLOGY

In the last ten years animal science has undergone momentous change. Gene transfer has become a reality, the limited cloning and sexing of embryos is feasible, and techniques for the predetermination of sex are progressing. New types of animals are soon likely to be manufactured by introducing genes from one species into another. These techniques open the possibility of inducing genetic resistance to major unresolved diseases such as trypanosomiasis and African Swine Fever, for the chimeric rescue of endangered species, and for using livestock for "molecular farming." Improvements in plants to enhance drought, salt, and pest resistance, to increase nitrogen fixation, and to change their composition expand the horizons in animal nutrition, as do the changes feasible in manipulating the microflora of the digestive tract of livestock. Relatively low-cost microbial factories are likely to be used to produce growth and lactation promotants, vaccines, and other pharmaceuticals.

Yet the likely application of these developments in helping resolve the problems of livestock production in developing countries appears to be very modest. Biotechnology in 1988 is essentially a commercial industry dominated by private companies operating for profit. The technical problems of medicine, agriculture, and industry in the developed world provide the most profitable markets for biotechnology and they are the focus of present research efforts which, in agriculture, center on the crops and livestock of the temperate zones. Some "trickle down" of biotechnology to the technical problems of the developing countries will certainly occur but, in the absence of major new initiatives, its impact on these problems is likely to be modest. Recognizing this, the United Nations International Development Organization (UNIDO) in 1981 sought to establish an International Center for Genetic Engineering and Biotechnology (ICGEB), but this approach has faltered due to the diversity of views of the members of ICGEB regarding its location, funding, and staffing. New efforts to stimulate the application of biotechnology to the problems of developing countries are needed.

Initial products of biotechnology likely to influence the pattern of future livestock production include new vaccines against specific diseases and against insect vectors, particularly ticks. The transfer of the growth hormone gene in mice, sheep, and pigs has now been accomplished. This gene can also be transferred to microorganisms and used to manufacture growth hormone in large quantities for commercial use, particularly in stimulating milk production from cattle. Wool production is normally constrained by the level of sulphur containing amino acids available to sheep, and by the cost of periodically shearing sheep to remove the wool. Biotechnology is reducing the importance of these constraints by transferring to sheep a gene enabling them to utilize a greater proportion of the sulphur ingested in pasture, while other groups have transferred to pasture plants a gene that increased their production of sulphur containing amino acids, thereby increasing wool production in sheep grazing these pastures. Wool removal is made much easier by the production, via gene transfer in microorganisms, of an epithelial growth factor (EGF) that can be used to cause a break in wool growth and its subsequent easy removal. Bloat control on high-quality pastures now looks possible via the transfer of a gene that incorporates into leaf protein tannins which occur naturally in the seed coat, thereby enabling a "bypass" of some leaf protein in the ruminal degradation process. The result is an improvement in the nutritive value of the forage as well as controlling bloat. The transfer of the nitrogenase gene to nonleguminous plants offers the prospect of greatly increasing the supply of better quality feed through biological nitrogen fixation, while the utilization by ruminants of existing poor quality and/or toxic feed and plants is enhanced by changing the cellulose and detoxication enzymes of rumen microorganisms.

As the successes of biotechnology develop it is now apparent that virtually all biotechnology processes and products will be patented, that the use of existing biotechnologies in developing countries will be dominated by the large transnational companies controlling patent and licensing royalties, and that research on specific problems amenable to biotechnology solutions in developing countries is likely to be undertaken in close collaboration with the laboratories in North America, Europe, and Australia that have established skills in the problem area. Much more collaborative research among the universities, public research institutes, and private companies in developed and developing countries is going to be required.

The main issues arising as a result of developments in biotechnology center on intellectual property agreements and patents. Recent court rulings indicate that virtually every technique, process, and product arising from biotechnological research will be patented; the ramifications of these decision are immense. Scientific communication and free technology transfer is being reduced, public expenditures on basic research topics are readily captured near their end point by means of specific production and marketing agreements, and germplasm long regarded as public property can be modified, patented in its modified farm, and sold to producers including those in the area in which the germplasm originated. The irritation of LDCs which originally provided some of this germplasm, and then have to buy it back in improved form, is now a major contention in international meetings. Protection of property rights in biological material centers on patents, and patent claims are only enforceable based on the DNA characterization of specific varieties and types of plants and animals. This characterization can now be achieved using a biological tagging that identifies specific genetic material, and which requires competence in the molecular patenting techniques essential to this task. The bottom line in all this is that unless a country has access to competence in biotechnology it will be a poor second in the scramble for increased livestock productivity.

STIMULATING LIVESTOCK PRODUCTION

The message that emerges from the experience of development efforts over the last thirty years is that the priorities in initiating sustainable growth in livestock productivity, coupled with wise land use, center on the difficulties of achieving an appropriate policy environment, difficulties that reinforce the use of better technology that leads to the creation of the increased cash flows needed for the fertilizer and other purchased inputs essential to better productivity.

The assistance provided by donors has shown considerable flexibility in responding to our increasing experience of the livestock development process. The first major initiatives in livestock development were made in the 1950s; they focused on technical assistance as the key tactic and attempted to achieve major advances by transferring technology from countries with well-established animal production industries. This experience then highlighted the need for increased flows of investment capital to specific project activities. In the case of the World Bank, international lending to livestock development increased from negligible amounts in the 1950s to about US$300 million per year in the early 1980s. Policy constraints then emerged as the priority, a topic which is now the subject of much attention. The need to provide more and better training and the strengthening of the research and animal health institutions serving the livestock industry have been a recurrent theme throughout.

Several further modifications are now desirable based on the notion that international support to livestock development should emphasize further the contribution of livestock to economic growth. Recognition of this broad benefit implies a different approach to the livestock development process; it leads to a search for the comparative advantage that livestock have in different farming systems in each country, and of development efforts that build on that advantage.

The second modification emphasizes the need for more innovations in the technology of livestock development, in feeding practices particularly, as a basic reason for the poor performance of livestock in the Third World lies in the seasonal inadequacy of the quantity and quality of feed available and in a failure to use local resources as well as is possible. The feed deficiencies that limit output are rarely tackled by strategic supplementation, yet there are many food sources for ruminant livestock that are poorly used; their better use could have a major impact on livestock output.

The third modification is one of enhancing the complementarities inherent in technical assistance, investment funding, and food aid, the three major contributions international organizations can provide. When the three come together in a well-coordinated program the results can be very impressive, as India's dairy operations illustrate.

The fourth need is to improve the access of developing country scientists to biotechnology and to published scientific material. The barriers to information and communication that so limit the work of scientists in the developing countries have to be overcome.

Critical as these changes are, there remains the overriding consideration of the problem posed by the surplus of dairy products and meat in the developed world. The cost of highly subsidized production and export of these commodities greatly overwhelms the contribution of all sources of agricultural assistance to developing countries and greatly reduces the effectiveness of our efforts to stimulate both crop and livestock output.

ANNEX 1. INDIA'S DAIRY PROGRAM

Small Farmers, Milk Production, and Rural Development

In India, milk is a by-product of a mixed crop and animal farming system, where the resources of milk animals, partly underutilized family labor, small farms, and draft animals are basic components of the rural scene. Cattle or buffaloes are kept by a large number of households, usually in small herds of two to four animals per household. Dung is used for fertilizer or fuel, and animal traction is a dominant motive for keeping cattle, with milk production at low levels and substantially below potential because of multipurpose animal use and limited feed resources. Increases in milk production allow for a better utilization of the available resources by providing a greater injection of regular cash income into the rural sector and a stimulus to rural employment. Many of the benefits of dairy development go to the poorer families in the rural sector, as the distribution of animals is much more equitable than the distribution of land.

The major impetus to recent increases in dairy production from small farms in India came from investments, largely in milk marketing, which enabled the collection of milk from widely dispersed producers in remote rural areas for sale in the major urban areas. The marketing process is based on cooperative dairy development which now follows the pattern set by the cooperative which developed around the town of Anand in Western India. The movement has grown from a small marketing cooperative into one offering a full array of input supply and technical services to livestock producers. It has developed a major national role in helping rural milk producers throughout India to set up their own milk cooperatives on the Anand pattern.

In implementing this rural development strategy, the Government limited its role to providing political support and the financial and institutional means to replicate the Anand pattern of dairy cooperatives on a national scale. Two agencies, one technical, the National Dairy Development Board (NDDB), and one financial, the Indian Dairy Corporation (IDC), were created, and IDC was given sole rights to import and resell milk products (mainly butter-oil and skim milk powder) in India. This enables India to use EEC surplus dairy products in a manner which does not distort or depress local markets.

NDDB grew out of the Anand Union which contributed the initial pool of skilled manpower. NDDB's role is to organize new cooperatives and provide them with technical services. To this end, it must assess the dairy production potential of a particular state or district, formulate the dairy development program including milk procurement routes and collection and processing facilities, depute spearhead teams to organize milk producer cooperatives, provide technical services for the delivery by cooperatives of production development programs, and carry out dairy plant construction and renovation on a turnkey basis. NDDB functions as a technical consultation and provides services for a fee. It does not own any plant or other production facilities.

IDC handles the imports and sale of dairy commodities provided as food aid to India, and the proceeds of International Development Association (IDA) credits, to finance cooperative dairy development. Financial assistance to cooperatives is provided as a mix of loans and grants for initial collection, transport, and processing investment as well as to ease cash flow problems in the first years of operation.

The dairy development policy has resulted in milk powder imports stabilizing at about 30,000 to 40,000 metric tons per annum over the past 15 years and declining substantially relative to production (from about 22% to less than 10%). In this period there was an estimated rise in aggregate milk consumption of between 4 and 6% per annum, due to a demographic growth of about 2.2% per annum, per capita income growth of about 2% per annum, and an estimated income elasticity of demand of about 0.8 to 1.3. Meanwhile, domestic milk prices have risen at slightly less than the general price index and food price index, and are equivalent to international border prices for reconstituted milk.

Milk production and processing costs in India are much lower than European and U.S.A. costs. In India, while whatever little natural pasture that remains will continue to decline, the availability and utilization of crop residues (straw and agricultural by-products) continues to increase and milk collection and processing costs still have room for improved efficiency levels. Potential growth in animal productivity through better animal husbandry, feeding, and cross breeding is large. The Indian dairy industry can be expected to become substantially more efficient over time.

Audit of the four completed IDA dairy credits to India indicates they have been very successful in assisting in the implementation of the national dairy plan. They have helped establish this self-sustaining process of rural development which is now being supported by a fifth IDA dairy credit to India of US$360 million.

TECHNICAL ISSUES IN ANIMAL AGRICULTURAL DEVELOPMENT

R.E. McDowell
North Carolina State University, Raleigh, NC

ABSTRACT

Assistance in livestock has undergone four phases of emphasis since 1950: improvement of stock through importations, animal disease control, direct transfer of technology, and farming systems. Each had merits and limitations but less success than anticipated. Need for a new phase has arisen in which greater emphasis is needed on packages that give farmers latitude of choice and government visibility with farmers. Capitalizing on experiences supported by well-designed research affords high prospects of more successful programs.

Among useful experiences are: differences in physiology of digestion and feeding behavior lead to each species of ruminant and nonruminant having a best niche which is quite important in utilization of resources in warm climates; meat and milk from all species have value; forage legumes afford opportunity for increases in both crop and livestock; programs for genetic change in stocks have not been accepted by farmers due to limits in feed resources; progress in control measures for animal health are good but delivery systems remain limiting; interest in animal traction is rising; and farmers are demanding choices in technology.

Research gaps remain. With high interdependence between crops and livestock a high priority is guidelines on linkages producing results useful to farmers. Research in animal health needs networking. Genetic improvement programs need testing on farms. In a broad context, nutrition of animals needs highest priority concentrating on principles underlying use of coarse forages. Forage agronomy with legumes and browse is highly supportable and so is low-cost methods of processing and preservation of milk. Small ruminant production can be expanded but research emphasis must include economics of application.

Technology for poultry and swine are available but need testing to reduce capital costs with use of local feedstuffs and generated equipment. Animal traction research requires focus on equipment to increase days of use for farmers to improve animal feeding. Biotechnology in embryo manipulation and reproduction offers promise but remains too costly but some in nutrition could be highly useful.

INTRODUCTION

Technical assistance in livestock production in developing countries started about 100 years ago but current approaches date from the early 1950s. Since 1950 assistance has passed at least four phases. Although this conference is concerned with the future, some comments on history and its shortfalls need recognition.

Phase 1 followed the success of UNRA in Europe during which time large shipments, principally cattle and poultry, went to the Middle East, parts of Asia and certain countries in Latin

America to serve as seed stock for the betterment of the livestock. Problems encountered in animal health gave Phase 1 a low yield.

During the 1950s and '60s (Phase 2) major attention was given to controlling plant and animal diseases. This was a high priority as the disease rinderpest, and to a lesser extent, foot and mouth disease, almost annihilated livestock in central Asia and Africa. Production of a cheap and reliable vaccine for rinderpest and certain other diseases gave satisfaction of progress but the corresponding rise in livestock production remained at the usual rate of about 1.3% per year because of feed supplies available.

To boost total food production, research, commencing in the 1960s (Phase 3), was oriented toward transferring technology that would achieve rapid gains in animal productivity (scientific and technological phase) using as a paradigm experiences in Europe and the U.S. Animal scientists gave emphasis to genetic improvement through crossing local livestock with males or frozen semen from the U.S. and in some instances made direct introductions of all major species. Warm climates offered an opportunity of high yields of plant biomass, so forage agronomists introduced cultivated forage species in high-rainfall areas and attempted to reseed rangelands in drier areas. This phase was based on the premise that much of the technology required for increased productivity existed. Emphasis was on having traditional societies adopt the new technologies, but again progress was far below expectations.

This period saw a rapid rise in donor and national government support for the Green Revolution. Technical scientists were pleased but social scientists commenced to point out inequities in benefits. A prominent example for livestock was the parade of researchers who went to Africa to decide what to do for livestock under drought conditions during the early 1970s. Assuming water was most limiting to livestock, donors supported borehole wells. This tended to concentrate stocks such that grazing was devastated within a radius of 8 km. Time proved that soil fertility, especially nitrogen, was most limiting. Low success of boreholes plus slow economic growth caused governments to lose prestige with farmers and led to retrenching to the safer priorities of animal health and genetic improvement of animal stocks.

Growing dissatisfaction with Phase 3 led to reassessment of development policies. Economic constraints and social institutions became relevant subjects for study, not as parameters that must change to fit particular technology, but rather as features needed to design technology. The long drought of the early 1970s in the Sahel and East Africa, coupled with recognition of shortcomings of the Green Revolution, probably gave greatest impetus to search for new approaches to research and development. It was realized that not enough was known about traditional systems, societal institutions, objectives of traditional producers, the economic environment, and constraints under which they were operating. More emphasis was laid on socioeconomic research to clarify some of the issues that emerged from failure of science to transform the productivity of these systems. Farming Systems Research (FSR) (Phase 4) developed a methodology to account for complex interactions of socioeconomic and technical factors. This more holistic approach has but marginally been implemented by most national institutions partly because of lack of trained socioeconomic researchers but, most important, suspicion on the part of governments that the "unproven approach" of interview and talk may add further risks in their relations to farmers.

As for the others, Phase 4 is being challenged as a development strategy. By 1985, USAID, other donors, and governments in developing countries began to seriously question the "cost-benefit" of farming systems research to growth in agriculture production. The value of better understanding of traditional systems is appreciated but investments have not contributed acceptably to Gross Domestic Product (GDP). Other issues pursuing the FSR approach are: the world feels researchers have not been able to overcome threat of drought; target countries continue to see high rates of urban migration; bungling of food aid distribution in Ethiopia in 1984-85; and pressures in the U.S., Canada, Australia, and Western Europe to better serve interests of national farmers. Other events, such as a new outbreak of the disease rinderpest in Africa, after donors had invested heavily in an eradication program during the 1970s with the promise that countries would continue annual vaccination, is considered a breach of faith. These trends have again stirred the pot on animal agriculture resulting in a decline in funding among developed countries for both domestic and foreign research in agriculture.

This conference is being held at an appropriate time as it corresponds to need for reexamining strategies for development. Much more is now known about constraints of the physical environments of warm climate regions, social and cultural constraints, and merits or limitations of animal species. If these are appropriately considered, prospects for further development in animal agriculture are quite encouraging. This report focuses on some of the known and yet unidentified problems in adapting or generating technology.

ANIMAL SPECIES

Accentuation in use of a certain animal species leads to oversights which can be quite critical, particularly in warm climates. About 95% of the time there is coexistence and complementarity between ruminants and nonruminants of importance in smallholder enterprises. Their competition is nil or low. Each can have a "best niche," depending principally on feed resources. For instance, at 43° north latitude cattle, goats, and sheep would be expected to return about equal efficiency in the utilization of 1 hectare of grazing, but not so in the north-south 30° latitudes because of the growth and maturing characteristics of grasses or legumes. Differences in feeding behavior and digestive physiology among animal species is quite important.

Ruminants

Most widely distributed ruminants are buffaloes, cattle, goats, and sheep, and to a lesser extent, alpaca, "banteng," camel, llama, yak, and game. Differences in digestive physiology, feeding behavior, pelage covering, and temperament largely determines distribution. If removed from their "normal habitat," modifications in environment are required. Buffaloes are the best users of coarse roughages and in tolerance to feeding on wetlands but are less efficient than cattle in use of high-quality forages. Cattle are efficient grazers. Of the two species *Bos indicus* (Zebu) is a more selective feeder and browser than *Bos taurus* (European types), hence, the Zebu is most popular in warm climates. Goats are required to be selective feeders. They select grasses when protein content and digestibility are high but shift to browse when leaves, bark, and fruits have better nutritive value. The same holds for numerous game species. Performance of goats may be low and mortality high on dry season grasses in subhumid areas or most grasses in the humid zone but will thrive in heavy covered browse areas where cattle may be hard-pressed to survive. Sheep are mainly grazers but body size requires they be selective in feeding. Feeding strategy (need for grass and browse), type of pelage, low reproduction efficiency, and temperament largely relegate alpaca, llama, and yak to high altitudes. Temperament and low reproduction rate limit the use of "banteng" although they can be efficient grazers. Camels are classed as intermediate feeders preferring grass but shift to browse when quality of grasses is poor. They are quite suitable to dry areas but their low tolerance to mud and slow growth rate restrict their best habitat. Readings on differences among ruminants are: Demment and Van Soest (1983), Gibbs and Carlson (1985), Hart and McDowell (1985), McCammon-Feldman *et al.* (1981), McDowell (1988a, 1987a, 1986), McDowell and Woodward (1982), McDowell *et al.* (1983), and World Bank (1987).

With appropriate mix, game animals can be efficient users of plant ecosystems. However, cost of harvest and marketing limit their potential as an economic unit for meat production. A number of the best species for meat do complement cattle very well in use of mixed grass-browse stands (McDowell *et al.*, 1983).

Nonruminants

Poultry are already high producers of food and are expanding in numbers. There are a number of other species important in certain areas, e.g., turkeys in Mexico and ducks in Southeast Asia. There is no blueprint for describing the role of these species in optimizing utilization of resources. The farming system and, more specifically, the crops and presence of other animals determines the importance of nonruminants within the systems. Production varies almost directly with cropping and availability of feed supply.

Compared to cattle and goats, investments by governments in poultry are quite low, yet the rate of their growth in several countries exceeds all other enterprises including crops. This indicates private enterprise is effective when markets are acceptable. Small crop farmers are supportive as poultry provides an expansion, as well as an alternate market for grains, especially when governments hold prices low. Poultry waste has value both for soil enrichment and as a supplement feed for ruminants. Growth is largely through direct transfer of technology: birds, feed, and equipment. Native poultry types are good scavengers but due to temperament do not adopt well to confinement rearing employed in intensive systems.

In a number of countries there is a rise in swine production through private enterprise using largely transferred technology. Increases in swine and poultry will continue. For many countries, poultry and, to a lesser extent, swine, demand for products may be doing more to stimulate grain production than technology.

Ducks tend to supplant poultry in humid areas. In much of Asia their main role is to glean rice from harvested fields and assist in control of weeds and insects. In high rainfall areas ducks survive better than poultry but they are usually not as good egg producers and their meat is less preferred.

There are numerous other species, e.g., guinea pig, guinea fowl, pigeon, rabbit, donkey, and horse, which could be expanded for meat production (Harris, 1985) or services, i.e., donkeys for traction. There is some knowledge of their nutritional needs and management techniques but more is needed.

Ruminants, particularly cattle, often influence cropping practices on farms, e.g., planting of maize where cassava may give highest yields, in order to have crop residues. Seldom are cropping practices determined by nonruminants, hence it frequently takes more effort to introduce them or raise their level of performance on small farms from a scavenger role to cash production. Of major concern should not be competition among species but determining which species will best utilize feed resources. Usually, this means keeping ruminants and nonruminants on farms.

ANIMAL PRODUCTS

Meat and Milk

Under most traditional systems cattle will gain at the rate of 150 to 250 grams/day and lactating cows yield 400 to 800 kg of milk per lactation. By maximizing management of farm resources, rate of gain may rise to 300 or 350 grams and milk yield of 1,500 to 1,800 kg. Beyond these levels of performance, supplementary feeds must be introduced from outside the farm. The goals for on-farm resources are worthy but technical problems in implementation are large. Among these are: need for change in cropping patterns, e.g., food crop rotation with forage legume for feeding; likely need for change in animal genotype; grading system at the meat market to compensate for improved quality of meat animals; sale of milk both morning and evening instead of once per day; appropriate infrastructure, such as vaccinations, drugs available to treat animal health problems, subsidized collection centers for milk or animals, and transport; and local sources of forage legume seed. If the goals are set higher, e.g., 450 to 600 grams/day growth rate and > 2,000 kg milk, the infrastructure must also include availability of processed feeds for supplementation. Historically, programs have focused on a single input, such as improved animal genotype, hence, few successes emerged on increased milk production. However, short-term "fattening" on small farms has reasonably good participation.

USAID and other donors have invested in goat and sheep programs with emphasis on meat and/or milk. Farmer adoption of technology is low due to oversights in feeding strategy and recommendations requiring cash outlays, which would need to arise from other farm resources since these species are largely used for home consumption or are bartered.

Under conventional systems a doe may yield 30 to 50 kg of milk, and a kid or lamb gain 20 to 40 grams/day. Program for milk yield of 100 to 120 kg per lactation, increased frequency of multiple births, and gains of 100 or more grams/day are frequently the targets. Most of the shortfalls for cattle are important, but of possibly greater significance is lack of recognition that more "specialized feeds" are required than for cattle and traditional use for noncash returns. Another problem has been markets for goat milk which would give acceptable returns to farmers. Fattening of goats or sheep from remote areas near urban centers for Moslem cultural celebrations has been quite successful. A major technical problem is getting commercial markets to attract goats and sheep in all seasons and to establish grading standards with price differentials for quality. Promotion of on-farm plantings of leguminous shrubs or trees for lopping as supplementary feed would greatly enhance use of crop residues by goats and sheep. Implementation of low-cost health treatments mainly for internal parasite control is needed.

A dilemma for programs oriented towards increased milk or meat for smallholders is the merit of raising the level of output from 1 or 2 animals per farm or encouraging specialization, e.g., 4 or more lactating age females in one herd and other farmers supporting through sale of feedstuffs. Intensification of labor for feeding and care of a single cow or buffalo to increase daily milk yield from 2 kg to 6 kg, coupled with a daily trip to market, is not attractive as compensation for additional investments. Trends in India serve to illustrate. In earlier times, women and children looked after the cows or buffaloes, did the milking, and sold the milk. When attempts were made to introduce technology for increasing milk output, men took more interest and assumed charge of income. Currently, a large group of "specialized keepers" are the main milk producers in villages keeping herds on the outskirts of towns with populations greater than 25,000 people. Cows or buffaloes are leased or sold to the "specialized producers." Farmers sell their crop residues or feedstuffs gathered all over. They made this choice of specialization. Thus far, farmers who cannot afford a cow or prefer to manage their labor differently have benefited.

Pastoralists and farmers distant from markets are using milk for protein and energy when there are high shortages of protein in urban centers. Low-cost methods of processing and preservation of milk would be helpful.

Fiber

For the past four decades, fluctuations in world prices of wool have been greater than could be tolerated by smallholder. This leads to pessimism of programs oriented to production of wool for commercial use. Production of handicrafts or needed household goods, such as outer garments and bed coverings from coarse wool sheep, can undergo some expansion. For this, local breeds or types are most useful but lead to low support for introduction of fine wool types, even though several countries in Latin America and Africa are seeking to bring in these breeds. The leaner carcasses from native breeds are most likely to receive more country and farmer attention for meat production. Assistance programs on meat production from sheep are promising.

World demand for mohair is raising. Several countries have introduced Angora goats to initiate an industry. The market is closely controlled in Europe, hence, risks on price stability will rise with production.

Hides

With the shift of shoe manufacturing to countries in the Pacific basin, the U.S. has become the leading exporter of hides. Due to higher quality of U.S. hides, demand from warm climate countries has declined. Although hides are a significant source of foreign exchange for over 30 countries, insect-damaged hides from warm climates do not have high promise for export. Technical problems on hides, their processing, and end products are going to be more a national priority than an international one.

ANIMAL NUTRITION

In the broad context, nutrition of animals should have highest priority with principal emphasis on increasing feed resources and "balancing of nutrients." Considerable research on utilization of locally available feedstuffs like by-products and on utilization of crop residues is conducted by the National Agriculture Research Services (NARS) but farmer adoption is low. There is little information on soil-plant-animal relations to serve as a basis for adjusting imbalances in animal needs in minerals, e.g., forages and crop residues are widely deficient in phosphorus. A few points on practical problems are given here.

There exists a major problem in crop residues. Studies have shown smallholders continue as low adopters of new cereal grain varieties, not so much because of lack of capital, but because these varieties do not provide crop residues as good in feeding value or for sale due to higher indigestible fractions. Maize stover of traditional varieties sells four times higher than improved varieties in Mexico, and in Syria stubble of native barleys for sheep grazing returns four times more. Stover and grain from bird-resistant varieties of sorghum have lower feeding value (Gibbs and Carlson, 1986; Hart and McDowell, 1985; McDowell, 1986). As presently practiced, selection for increased yields of grains in food crops significantly affects feed quality of residues as there is a positive correlation with plant content of low digestibility (hemicellulose) and indigestible fractions (lignin) in the plants and high grain yield. Preliminary evidence indicates this does not need to hold (Reed *et al.*, 1986), therefore, plant breeders ought to give more attention to utilization of the whole plant.

Recommended technology is generally directed to neonatal young and lactating females. Poor nutrition in late stages of pregnancy result in small offspring with low vigor. In does and ewes low nutrition, the last month of pregnancy will result in a delay in letdown of first milk (6 to 24 hours), resulting in high mortality of their offspring. Calves may gain well (> 300 grams/day) for the first few months, but subsequently drop to 100 to 200 grams, leading to "stunting" which produces cows which will not respond efficiently to improved feeding during lactation. Assistance programs for increased animal performance must give greater attention to development of replacement females (McDowell, 1985).

REPRODUCTION

Low reproduction rate of livestock of warm climates, as measured by age of first parturition, intervals between parturitions or percentage of young per year is frequently used to give high priority to research. But reproductive efficiency in warm climate areas will be satisfactory when: females are healthy, nutrition is sufficient to ensure cycling; females are at a steady weight or gaining; and females are attended with vigorous, fertile males. What is the problem? Low fertility is to a large degree a temporary reaction to negative energy balance, or stress from climate, disease, or parasites, all of which will cause temporary to permanent sterility. Technology in the form of hormone therapy is not recommended to overcome anestrus or synchronization of estrus because of countereffects caused by environmental conditions. Studies of animal behavior in relation to local environments is the primary need, coupled with interactions with farmers on their priorities for breeding. More frequently than generally recognized, farmers are aware of what can be supported by their resources and do a much better job of planning on rate of breeding.

BREEDING PROGRAM

Space will not permit delineation of the merits and limitations of improved breeds, crosses, and native-type stock of all species. Comments are offered on cattle with the same principles applying to other domestic livestock. Nevertheless, planning for breeding is extremely important as it represents a long-term commitment.

Often, expatriates view locals as having low knowledge of animal breeding but this is not so. India has over 30 breeds of cattle; Africa has 50 breeds of cattle and equal number of types of goats and sheep which were developed before Westerners became concerned about animal genotypes in these areas. Assistance programs ordinarily project changes in farmer goals more rapidly than can be achieved through normal selection processes, thus we have rushed to change animals in most countries.

Best biological efficiency (utilization of feed energy) for milk yield from cattle in warm climates is 4,200 to 4,500 kg per lactation. Above this level the utilization of feed energy for milk production is lowered because of environmental stresses. Well-managed improved grass pastures will support an annual herd average of 3,000 to 3,200 kg of milk. Natural grasslands and/or crop residues, along with 3 kg of concentrates per day will sustain 1,800 to 2,200 kg of milk. Since feeding level is important in overall performance, no specific breed or crossbred is best for the range of conditions prevailing within each country. Fitness is also important in efficiency of functioning, therefore, the following is recommended for milk cattle:

Resources will support milk	Recommended type animal
> 4,000 kg	Pure European dairy breed or 3/4 cross
3,000 kg	Dairy cross 50-65%
2,000 kg	Dairy cross 25-50%
< 1,500 kg	Dairy cross 25% or native

In traditional smallholder systems, lactating cows are fed 115 to 125% of their basic maintenance requirements and will produce 1 to 3 kg of milk per day. They will usually respond efficiently to increased feeding up to 150 to 180% of maintenance. This means milk yield will rise from 400-600 kg to 1,000-1,500 kg. The wide range in response depends on growth rate at early ages and the animal's temperament toward milk extraction by hand or machine. A native cow on average farms receives 3.3 to 3.8 kg of total digestible nutrients (TDN) per day and government stations 4.5 to > 5.0 kg TDN, but to effectively use milk breeds like Holstein, about 10 kg of TDN per day required. This level is usually far above attainment by smallholders. In India, the cost of producing 1 to 2 kg of milk per day from a dairy x local breed crossbred is twice that for native cows. Cost of milk production by dairy breed -- native crossbreds falls below that for native only when yield is > 5 kg/day. To make use of crossbreds effective the question becomes "can conditions be provided on an economic basis which will support > 6 kg of milk per day?" The general conclusion is that change in genotype by introducing improved breeds is unwarranted until feeding is > 170% (about 6 kg of TDN) of maintenance needs (Aluja and McDowell, 1984; McDowell, 1988d, 1987a, 1987c, 1985). A second caution is that local types have resistance to diseases which can be important and they have capability of responding in milk yield to seasonal effects (wet, dry) better than improved breeds or crossbreds.

On many occasions improved breeds from outside have been used to produce crossbreds. The first generation or F_1 cross-performs satisfactorily. The general perception is that 50% improved breeding is good, more must be better, hence, a grading-up scheme using improved breed of sire is followed but at the 75% level (second generation) heterosis or hybrid vigor declines. The 3/4 or 75% improved breed cross is quite subject to environmental stresses resulting in high mortality, long parturition intervals, and usually lower milk yield. More than one country has encountered the wrath of farmers following an upgrading program because about 50% more feed is required for 3/4 crosses while hybrid vigor is not forthcoming. The challenge of the future will be to either introduce less than 50% improved breeds or identify breeding plans to maintain the level of performance of the F_1 cross. The same holds for goats, sheep, swine, poultry, and other species.

PHYSIOLOGICAL ADAPTATION

In the early years of warm climate assistance programs there was high emphasis on "selection for heat tolerance." Making breed or species comparisons based largely on body temperature and respiration rate showed that rises occurred when animals are exposed to midday sun. Output in usable results has been low. McDowell and Woodward (1982) used 56 traits to estimate possible advantages and limitations of cattle, goats, and sheep for warm climates. If all traits were given similar consideration in judging suitability, goats would be favored over cattle for 16 traits and superior to sheep in 18; however, cattle would be expected to rate better than goats in 35 traits and sheep over goats in 20 traits.

If a decision on choice of species is required, obviously environmental conditions, principally amount and type of feed resources, and the extent it is economically feasible to make manipulations, become primary considerations. The goat, for example, has certain uniquenesses which can make it highly suitable to certain environments but its qualities are not universally advantageous. Given an opportunity for a high degree of selective feeding, the goat is as efficient or more so than cattle or sheep but when the degree of utilization of total plant biomass is the criterion of measure, the goat's comparative efficiency is low.

Much has been written on possible merits and limitations of Zebu types and European origin breeds of cattle. The latter have good to excellent potential for growth rate and milk yield but their fine tuning for performance lessens fitness for low levels of environment. Zebu type cattle prevail in most of the warm climate countries, not for heat tolerance per se, but because of feeding behavior. Zebus are slow to reach puberty, hence, there is less urge to eat. They have nearly 25% less digestive capacity per unit of size. This forces them to be slower and more selective feeders than Holsteins, for example. In the coarse grass areas, it is unwise to replace Zebus with European breeds; however, Zebus are less efficient in the use of crop residues than European types and buffaloes due to lower fermentation rate in the rumen and faster rate of passage through the digestive tract. On tropical grass pastures, Zebus will select a higher quality diet but will utilize less of the total forage dry matter. European breeds tend to make best use of improved pastures; Zebus will do best on natural grasslands and buffaloes are best where opportunity for selection is lowest, e.g., rice straw.

ANIMAL HEALTH

In general, assistance programs supporting animal health have received high attention as a consequence of available technical expertise and visibility among farmers, which governments like when disease control is effected.

State of the art on control of several major diseases are:

- Rinderpest. There is a reliable vaccine but it could be improved by making it thermostable.

- CBPP (contag' 's bovine pleuro-pneumonia). Immunity for one year can be maintained with vaccination.

- PPR (*peste des petits ruminants*). Vaccine used for rinderpest gives good results.

- Anthrax, Blackleg, Pasteurellosis. Available vaccines are adequate.

- African Swine Fever. No effective control beyond slaughter exists. Research on control is urgently needed.

- Trypanosomiasis. No complete effective control exists. Because of the complexity of the pathogen, development of a vaccine has low probability. Control of the vector (tsetse fly) through use of traps or impregnated screens with artificial attractants is promising as aerial spraying is expensive and clearance is not permanent and/or is environmentally harmful. Research on attractants, use of sterile males and search for tolerance in certain breeds of cattle are high priority.

- Dermatophiliasis or cutaneous streptotrichosis. As yet there is no control. More investigation on control is needed.

- Gastrointestinal Parasites. They probably cause the greatest losses among livestock mainly in morbidity. Drugs for control are available but additional research is needed on integration into existing management systems.

- Tick-Borne Diseases. Research to assess the extent promising results on East Coast Fever vector control can be applied to vectors of piroplasmosis and heartwater (DeHaan and Nissen, 1985; World Bank, 19L).

Considerable technology is available for control of major diseases but the technology generally lacks effectiveness due to inadequate delivery systems. Of equal significance is that animal health programs have not been accompanied by improvement in nutrition and management. Many countries have considerable national veterinary staff and laboratory resources that are not effectively employed due to shortage in funding. Also, the approach to animal health research is fragmented with each laboratory attempting to cover a whole host of diseases.

BIOTECHNOLOGY

There is considerable biotechnology available or nearly so which has potential use in warm climates. Some are:

- Embryo manipulation

  - External fertilized embryo
  - Cloned embryo (division fertilized embryo)
  - Improve resistance to certain diseases (embryo manipulation)
  - Sexing of semen

- Reproduction

  - Artificial insemination
  - Estrus detection devices
  - Progesterone milk assay for estrus and pregnancy
  - Synchronization of estrus

- Nutrition

  - Bovine somatotropin (BST)
  - Feed preparation to bypass the rumen
  - Laboratory techniques for quantifying chemical inhibitors in plants

The chief inhibitor to use of all these features is cost which includes support for needed infrastructure. Artificial insemination (AI), for example, may be desirable for genetic changes and for health control but requires subsidy. In the U.S., the cost per conception is equivalent to about 0.5% of returns from the cow's milk which users can afford, but in India the cost is equivalent to nearly 10% of milk value and over 12% in most of Africa. But AI has the value of contact between persons with some technical skills and farmers, thus its "real value" in livestock production may be different from the economic value.

Transfer of fertilized embryos and embryo splitting (cloning) have potential, e.g., rapid expansion of N'Dama cattle which have genetic resistance to trypanosomiasis, but as yet is too costly except in selected situations. In the U.S. embryos are selling for $300 to $1,000 each, exclusive of placement costs in surrogate mothers with 50% successful calvings. With 2.2 to 2.5 pregnancies needed per usable female, general use awaits much lower cost. In warm climates successful implantations will likely be 50 to 300% lower than in countries with a high level of infrastructure. Cloning has produced success in offspring only experimentally thus far. Sexing of semen is close to reality but again economics will be limiting.

Because of stresses on animals in warm climates, use of estrus detection devices and hormone therapy for synchronization of estrus have practical limitations.

The best potential at present is in nutrition. BST use is associated with higher milk yields with greater efficiency but more feed is required. A surprising result is that treated cows respond by eating more coarse roughages which could be of possible use in warm climates as an appetite stimulator. When concentrates are used, pelleting and coating in order to bypass the rumen affords opportunity to realize more return from use of costly concentrate feeds. Use of laboratories to identify constraints to animal utilization of browse and other feeds can be a real breakthrough in feeding as there are certain possibilities to manipulate bacteria in ruminants for more effective use of browse, e.g., rumen inoculation to reduce or eliminate toxicity problems from mimosine in *Leucaena*.

RESEARCH GAPS

> "In many cases livestock and livestock products are the most important source of cash income of subsistence farmers. Small improvements in livestock productivity

quickly results in important income changes and in the availability of funds to improve the subsistence cropping patterns that characterize smallholder agriculture." (Brumby, 1987).

Crops/Livestock Associations

With high interdependence between the two major subsystems, crops and livestock, on small farms, as implied by Brumby, a high priority for research is on policy guidelines at national levels to develop linkages which will produce results useful to farmers. A major feature should be development of packages of practices which will give farmers a choice of options, as choices become motivating forces. National research organizations are now seeking help and guidance on new crops for local testing. This request stems from a desire by farmers to have alternate crops which can be substituted when government controlled prices are too low for passive returns, increase their ability to compete in national markets, and have feed for livestock. The same holds for milk products.

Animal Health Technology

Research in animal health must continue with high priority but more planning should go into coordination of activities and some shifts in emphasis, e.g., more research and training in epidemiology focusing on problems of mortality in neonatal animals. Considerable national staff and infrastructure exist in the veterinary field which needs intensive focus on epizootiology of local disease patterns, particularly in gastrointestinal parasitism and tick. ICIPE's tick work needs to include additional species and tick-borne diseases.

Genetic Improvement

No country in warm climates has been able to formulate a national policy on genetic improvement. Basic knowledge on appropriate genotypes is available, but governments tend to favor crossbreeding projects since they provide visibility of effort on behalf of farmers. Priority should be shifted to gathering and evaluating field data on local stocks to establish their merits and limitations, preparatory to determining which traits require adjustments through outside introductions. This is especially the case for small ruminants. Genetic improvement efforts should shift from on-station work to performance recording on farms with national institutions supporting recording systems.

Animal Nutrition

Major gaps in appropriate technology are: poor collation of research already conducted; low attention to on-farm research; identification of major limitations in feedstuffs available, mainly content of chemical inhibitors (phenols); recognizing that principles underlying efficient use of coarse pastures and crop residues centers on maximizing their utilization instead of achieving an optimal nutritional status of animals; and low coordination between plant breeders and animal nutritionists on quality and use of the whole plant.

Range Management

The first priority in range research should be consolidation of results followed by reassessment to identify researchable problems. Rangelands should be viewed as a specific resource which can be converted within limits to human usable products. This requires a parallel strategy for generating external feed resources.

Forage Agronomy

There are many potentially useful forage and bush legumes and leguminous trees in warm climate countries, but a well-managed germplasm collection to support research on species resistant to disease and adapted to low phosphorous soils is needed. Possible plant response to low-grade phosphate from local source should be a high priority.

Milk Products

There is an urgent need for research on low-cost methods of processing and preservation of milk to the benefit of both rural and urban residents. Research on methodology and equipment requirements to produce quality cheese, butter, and fermented milk could help reduce imports and help in rural development.

Small Ruminants

With increasing pressure on land, goat and sheep numbers will rise. Performance of these species in existing systems is better than generally assumed. Interest to expand research with strong emphasis on health and nutrition is high. But programs directed to expansion of numbers and productivity must include investigation of the economics of application. Adequate identification of problems is essential to make best use of the interest of donors and enthusiasm in the international community for more attention to small ruminants.

Poultry

Technology can be drawn from western countries on breeds, nutritional needs, and disease control. First priority should be given to evaluation of the technology for intensive systems to warm climate conditions, coupled with evaluation of the use of feedstuffs for which an area has comparative advantages, e.g., use of sorghum or rice versus maize. A further need is investigation of substitution of less expensive housing and equipment produced locally.

Swine

Rises in swine production have resulted mainly from commercial units located near urban centers created by the private sector. Most proposals for support include high emphasis on facilities for research on diseases and strain (new breed) development. These are difficult to support on a national basis as most health problems, except African Swine Fever, are confounded with nutritional stress. The highest priority for government-supported research should focus on utility of local feedstuffs and control measures for African Swine Fever. Testing for modification of intensive production technology is also highly desirable.

Other Animals

Potential for use of numerous other animal species for meat, e.g., rabbits, or milk, e.g., camels, is excellent. But if the chosen species is not already present on local farms, its suitability to local environmental conditions, especially adequate feed resources, must be determined. Should environmental modifications be required, economics of adjustments are essential.

Animal Traction

Although not included in the terms of reference for this report, traction is an important feature in the services provided by animals. Interest in research is rising but priorities need reevaluation. Full assessment of the contribution of draft animals to farming systems is not adequately identified in nutritional studies to improve capability for power. Where land preparation is the primary use (10 to 30 days per annum use), nutrition is usually not given high priority by farmers. When the number of days for work can be increased to include crop cultivation, transport, earthmoving, etc. (> 60 days/year), improvement of feed supplies will be more acceptable to farmers. Improved feeding, animal training, and investment in harness or equipment are positively correlated with use of animals. The most urgent need is in equipment design for tasks like weeding, water harvesting, and erosion control. Implements must be durable, low-cost, and suitable for powering by oxen weighing ≥ 300 kg. There is also need to develop the capability of local artisans who have potential in developing appropriate tools and low-cost maintenance.

Networking

This is not intended as a research area *per se*, but there is a strong need by assistance agencies to promote cooperation between individual NARS through networking. This approach is especially useful in livestock programs, e.g., the International Livestock Center for Africa (ILCA) has several successful programs in Africa. Among the highest priorities are disease research due to the high cost of duplicating laboratory facilities. Other worthy activities are production systems research, legume agronomy, agroforestry, and animal traction.

Conclusions on Research

With exceptions of veterinary medicine, animal traction, intensive poultry, and swine production research, the impact on livestock production has been lower than anticipated. A concerted effort is essential if present trends of scant supplies, rising demand, large deficits in animal products, and resource degradation are reversed. A strong capacity of NARS to conduct livestock research is not only crucial to their impact but also to adoption of technology generated by international livestock research.

As viewed by outsiders, national research programs have largely focused on the "vertical approach," i.e., specializations by subject matter or commodity with low regard for how specialized recommendations may create or cause undesirable interactions when implemented, e.g., crop-livestock subsystems on farms. There is a critical need for more manpower capable of a "horizontal approach," i.e., personnel who can collate decisions on animal health, nutrition, reproduction, breeding, etc. (have managerial skills). Disappointments in input-output relations for livestock will continue until national policies are geared to "productive husbandry" (goals in output per animal) instead of livestock preservation.

The need for a new phase in development is at hand. Capitalizing on what is known or can be reliably estimated, there are vast opportunities to increase the contribution of livestock both in human food and services. A significant factor now existing which did not earlier is the much wider recognition among disciplines outside animal science of the importance of animals to smallholder farms and gre:.ter emphasis on sustainable production systems focused on the complementarity of cropping and livestock on small farms is viable and mandatory.

REFERENCES

Aluja, A., and R.E. McDowell. 1984. *Decision Making by Livestock/Crop Smallholders in the State of Veracruz, Mexico.* Cornell Int'l. Agri. Mimeo. No. 105. Cornell Univ., Ithaca, NY.

ARNAB. 1987. *Utilization of Agricultural By-products as Livestock Feeds in Africa.* International Livestock Center for Africa, Addis Ababa, Ethiopia.

Blond, R.D., ed. 1987. *A Five Year Report of the Small Ruminant Collaborative Research Support Program.* Repro Graphics, Univ. California, Davis.

Brumby, P.J. 1987. *Livestock: A Sector Policy Paper.* World Bank, Washington, DC.

Ciggs, M., and C. Carlson, eds. 1986. Crop productivity - Research imperatives revised. An international conference held at Boyne Highlands Inn, Oct. 13-18, 1985 and Aridre House, Dec. 11-13, 1985.

DeHaan, C., and N.J. Nissen. 1985. *Animal Health Services in Sub-Saharan Africa: Alternative Approaches.* World Bank Technical Paper No. 44, Washington, DC.

Demment, M.W., and P.J. Van Soest. 1983. *Body Size, Digestive Capacity, and Feeding Strategies of Herbivores.* Winrock International, Morrilton, AR.

Gupta, P.R. 1988. Dairy India 1987. *Dairy India Yearbook.* Delhi, 110092, India.

Hart, R., and R.E. McDowell. 1985. *Crop/Livestock Interactions as Determinants of Crop and Livestock Production.* Cornell Int'l Agri. Mimeo No. 107. Cornell Univ., Ithaca, NY.

Harris M. 1985. *Good to Eat: Riddles of Food and Culture.* New York: Simon and Schuster.

IFS. 1987. *Workshop on Swine and Poultry Husbandry.* Provisional Rpt. No. 22, International Foundation for Science, Stockholm, Sweden.

ILCA. 1987. *ILCA's Strategy and Long-Term Plan: A Summary.* International Livestock Center for Africa, Addis Ababa, Ethiopia.

Jutzi, S., F.M. Anderson, and A. Astatke. 1987. *Low-Cost Modifications of the Traditional Plough for Shaping and Surface Drainage of Heavy Clay Soils.* ILCA Bul. No. 27, International Livestock Center for Africa, Addis Ababa, Ethiopia.

McCammon-Feldman, B., P.J. Van Soest, P. Horvath, and R.E. McDowell. 1981. *Feeding Strategy of the Goat.* Cornell Int'l Agri. Mimeo No. 88. Cornell Univ., Ithaca, NY.

McDowell, R.E. 1988a. Importance of crop residues for feeding livestock in small holder farming systems. *Proc. Workshop: Plant Breeding and Nutritive Value of Crop Residues.* 'nternational Livestock Center for Africa, Addis Ababa, Ethiopia.

_______. 1988b. Approaches and methods of research and extension for small-scale livestock production systems. *Proc. Workshop: Research and Extension for Livestock in Communal Area Farming Systems.* Liv. and Pastures Div., Min. Agri., Harare, 'imbabwe, Feb. 16-18, 1988.

_______. 1988c. Appropriate technology to enhance livestock production in the tropics. *Proc. 2nd Nat'l Liv. Improvement Conf.* Institute Agri. Res., Addis Ababa, Ethiopia, Feb. 24-26, 1988.

_______. 1988d. Strategies for genetic improvement of cattle in warm climates. *Proc. 2nd Nat'l Liv. Improvement Conf.* Institute Agri. Res., Addis Ababa, Ethiopia, Feb. 24-26, 1988.

_______. 1987a. Matching the animal to the environment: Cattle. In *Forage-Livestock Research Needs in the Caribbean Basin*, edited by J.E. Moore, K.H. Quesenbury, and M.W. Michand. Caribbean Basin Advisory Group, Institute of Food and Agri. Sci., Univ. Florida, Gainesville.

_______. 1987b. Ethical aspects of food and policies for Third World countries. *Proc. Workshop: Ethical Aspects of Food, Agriculture, and Natural Resource Policy.* Dept. Sociology, Univ. Kentucky, Lexington.

_______. 1987c. Environmental and genetic factors influencing performance in Holsteins in warm climates. *Proc. Workshop: Dairying in a Tropical Environment*, Taichung, Taiwan. Holstein-Friesian Assoc., Brattleboro, VT.

_______. 1986. *An Animal Science Perspective on Crop Breeding and Selection Programs for Warm Climates.* Cornell Int'l Agri. Mimeo. No. 100. Cornell Univ., Ithaca, NY.

_______. 1985. *Meeting Constraints to Intensive Dairying in Tropical Areas.* Cornell Int'l Agri. Mimeo No. 108. Cornell Univ., Ithaca, NY.

McDowell, R.E., and P.E. Hildebrand. 1980. *Integrated Crop and Animal Production: Making the Most of Resources Available to Small Farms in Developing Countries.* Working Papers, The Rockefeller Foundation, New York, NY.

McDowell, R.E., and A. Woodward. 1982. Concepts in animal adaptation: Comparative suitability of goats, sheep and cattle to tropical environments. *Proc. 3rd Int'l. Conf. on Goat Production and Disease.* Scottsdale, AZ: Dairy Goat Journal Publishing Co.

McDowell, R.E., D.G. Sisler, E.C. Schermerhorn, J.D. Reed, and R.P. Baver. 1983. *Game or Cattle for Meat Production on Kenya Rangelands?* Cornell Int'l Agri. Mimeo. No. 101. Cornell Univ., Ithaca, NY.

Peters, K.J. 1987. *Unconventional Livestock: Classification and Potential Uses.* ILCA Bul. No. 27, International Livestock Center for Africa, Addis Ababa, Ethiopia.

Peters, K.J. 1987. *Evaluation of Goat Populations in Tropical and Subtropical Environments.* ILCA Bul. No. 28, International Livestock Center for Africa, Addis Ababa, Ethiopia.

Reed, J.D., A. Tedla, and S. Jutzi. 1986. Large differences in digestibility of crop residues from sorghum varieties. Res. Briefs, *ILCA Newsletter* 5:5. International Livestock Center for Africa, Addis Ababa, Ethiopia.

Sumberg, J.E., J. McIntire, C. Okali, and A. Atta-Krah. 1987. *Economic Analysis of Alley Farming with Small Ruminants.* ILCA Bul. No. 28. International Livestock Center for Africa, Addis Ababa, Ethiopia.

Thomson, E.F., P.S. Cocks, and F. Bahhady. 1986. *Improving Feed Resources: A Key Step Towards Expanding Ruminant Production in Semi-arid North Africa and West Asia.* Internal Publ. No. PFLP-15, ICARDA, Aleppo, Syria.

U.S. Congress OTA. 1988. *Enhancing Agriculture in Africa: A Role for U.S. Development Assistance.* U.S. Congress Office of Technology Assessment, Washington, DC, U.S. Gov't Printing Office. In press.

Wilson, R.T. 1984. *The Camel.* Longman, Group Ltd.

World Bank. 1987. *West Africa Agricultural Research Review 1985-86.* World Bank Western Africa Projects Dept., Washington, DC.

World Bank. 1987. *East Africa Agricultural Research Review 1986.* World Bank Eastern Africa Projects Dept., Washington, DC.

SELECTED ISSUES IN ANIMAL AGRICULTURAL DEVELOPMENT: RUMINANT NUTRITION

A.L. Pope
University of Wisconsin-Madison

INTRODUCTION

There are many important issues in animal agriculture today; thus it was difficult to choose one for discussion in this paper. Nutrition was selected because it is the foundation of animal productivity. As Dr. McDowell has indicated, the potential of improved breeding for milk and growth cannot be realized if nutrition is not improved. Better reproduction which includes shortening the interval between births and raising more young depends greatly on the nutrition of the dam. Likewise, the health of animals and their resistance to disease and parasites is influenced by the nutrition the animal receives. The productivity of animals in the developing world has not increased since 1950 in large part because the feed supply has decreased.

This is indeed unfortunate in light of the growing human population. Total protein from animal sources globally is nearly equivalent to that from wheat and corn and about half that from all cereals (McDowell, 1979). The total protein level in the diet of humans in the developing countries remains at approximately one-half that in developed countries. Most estimates for developing countries show animal products contributing between 12 and 35% of their dietary protein intake (Cunha *et al.*, 1977). The quality of increased food production should be considered so that essential proteins are provided. The meat of animals is a good source of B vitamins and minerals, especially important to women and to children under 5 years of age. These children make up over half of the world's malnourished population (Presidential Commission on World Hunger, 1980), (Cunha, 1982).

About 40% of the cattle, 50% of the sheep, 90% of the goats, and 99% of the buffalo in the world are in the developing countries. Small ruminants (sheep and goat) are especially important to these small farmers. It is estimated that the world has about 100 million small farmers (Fitzhugh *et al.*, 1978). FAO projects sheep and goat numbers will have an annual increase of 2.0% in numbers and 3.6% in production in 90 developing countries. Cattle and buffalo for milk production will increase 2.7% and 3.7% for numbers and production, respectively (FAO, 1979). The demand for animal products, therefore, will continue to increase and the sustainability and improvement of animal production to realize this potential is possible and essential.

RUMINANT NUTRITION

> "Food for animals comes principally from six sources: grazing of cropland under fallow, crop residues, pastures and forges, by-products of food processing, and cereal grains. Less than 1% of the animals useful to humans receive foods directly consumable by humans. Much more food grains are lost in storage to rats, insects, and molds than are fed to domestic animals." (McDowell, 1984).

The subheading of this section is technical and so I wish to zero in on the uniqueness of the ruminant to utilize very fibrous crop residues such as cereal straw, maize stover, and mature grass. Much of the energy of these residues is bound tightly in cell wall cellulose, hemicellulose, and lignin and cannot be utilized by monogastric animals including man. It is estimated that there are up to 2 t of crop residue dry matter available in developing countries to feed livestock for each 500 kg of livestock unit. In farming systems from Latin America to Asia crop residues account for 30 to 90% of livestock feed (McDowell, 1988). Dr. Peter Brumby has stated at this symposium that increased livestock production in the future must be based on ruminants consuming coarse roughage.

Considerable knowledge has been forthcoming in the past two decades on how these very coarse, fibrous residues can be improved as animal feed. The research has been in three main areas:

- research with rumen microbes
- chemical treatment
- supplementation

Rumen Microbes

Rumen microbe research is most complex. There are so many different microbe species and in such great numbers that if one species is modified others fill in to take up the work or function. There are studies now on individual strains of microbes but the application of results is far down the road. And so the discovery of that "super" cellulytic microbe that will make even sawdust digestible is not on the foreseeable horizon.

Research with rumen microbes has involved studies to determine the nutritive requirements of rumen bacteria to improve their ability to break down cellulose and hemicellulose resulting in increased energy and protein yield. It is well established that nitrogen (N) is needed in low protein diets. When a low N basal diet is supplemented with urea, a source of carbohydrate is required. A urea-molasses supplement is generally beneficial. Another example is the need for sulfur (S) for production of sulfur-bearing amino acids and maximum digestibility of fiber (Moir, 1975). Kennedy and Siebert (1972) found sheep ate more and digested more poor quality grass with sulfur supplements. A ratio of 1:10 S:N is most effective (Bull, 1979). While there is voluminous research results in the literature reporting the benefits of urea as a source of N, little mention is made of the importance of its relationship with S in the use of urea in developing countries.

Investigation into the ability of rumen microbes to metabolize secondary plant compounds such as cyanogenic glycosides, gossypol, and mimosine has gone far to improve feeds for ruminants. The legume *Leucaena leucocephala* has great potential as a feed supplement but contains mimosine which is toxic. The discovery of rumen bacteria that break down this compound into a nontoxic rumen metabolite is of great importance. "The discovery that bacteria can break down the toxic (3-hydroxy-4(H)-pyridone) (DHP) derived from mimosine into a non-toxic metabolite is an important discovery. It reveals a specific mechanism for dealing with toxins that is new to scientists. It is the first known example of a form of co-evolution between plants and their rumen predators that may be more widespread than previously suspected. In the future the routine laboratory analysis for protein and fiber constituents will not be enough. The role of secondary plant compounds and how the animal adapts and rumen microorganisms detoxify and at what rate must be better understood. This should increase the ruminant's ability to utilize even a wider variety of plants more efficiently." (Reed and Chater, 1988).

What will biotechnology contribute to more efficient rumen microbes in the future? While biotechnology in animal research will impact on animal health through improved diagnostic tests, vaccines, and treatments; on reproduction through improved hormone production, embryo transfer, and sex determination; and genetic improvement through gene transfer and cloning, its effect on improving fiber digestion of ruminants holds less foreseeable promise. Any genetic engineering will come slowly and will not provide a panacea of results. This is because of the many different microbes and the complexity of the rumen environment. "Both on particulate digesta and on rumen epithelial tissue, bacteria associate with related organisms and function as a consortium, one organism growing on the end products of metabolism of another. Within the rumen there are often very close associations of bacterial species, dependent on simple materials liberated by each to the mutual benefit of both (syntropic associations). These interactions of rumen bacteria appear to be highly beneficial and there appears to be little that can be done to manipulate these associations other than inhibition of methanogenesis." (Preston and Leng, 1985).

Chemical Treatment

Chemical treatment of crop residues has included sodium hydroxide, calcium hydroxide, ammonia, and ammonia precursors such as urea and even animal urine. The effect of these treatments has been significant. Digestibility of cereal straw is increased 5 to 10%, N content 1% of dry matter and voluntary intake 25 to 50%.

In the industrialized countries the application of sodium hydroxide and ammonia is the treatment of choice with preference to the latter because it is less caustic on equipment and N is added instead of sodium. Steam heating and most recently alkaline-hydrogen-peroxide are used. There, of course, is great difficulty in applying these techniques to the smallholder in developing countries.

Much simpler methods involve the use of more accessible urea as a source of ammonia. Straw is sprinkled with urea dissolved in water and placed in a bamboo basket and plastered with cow dung and mud to make the container air tight. After 10 days to 6 weeks the straw is fed to cattle (Khan and Davis, 1981). Saadullah *et al.* (1980) and others have treated rice straw with animal urine. The straw was treated and stored in a similar manner as described for adding urea. The mixture was stored for 20 days and fed to sheep. The crude protein content of straw was improved from 3.3% to 5.6% and N balance from -2.94 grams to -1.15 grams. Dry matter, organic matter, and crude fiber digestibilities went from 38%, 45%, and 56% to 51%, 55%, and 62%, respectively. The intake of dry matter increased by more than 70%. From these results and others it would seem that both urea and urine treatment of rice straw can give improvement nearly comparable to anhydrous ammonia used in industrialized countries.

Another economical and available source of alkaline material is wood ashes. Nolte *et al.*, (1987) have demonstrated that treatment of wheat straw with a 30% alkaline solution of wood ashes effectively improved fiber utilization by ruminants.

Supplementation

Supplementation of treated or untreated cereal straw is necessary if any improvement in growth or production of milk is to be obtained. This is especially true of N and the resulting ammonia levels which are necessary to maximize the degradation of a fibrous substrate in the rumen. Supplements that have proved beneficial are molasses/urea blocks previously mentioned and green forage. Leaves of the green *Gliricidia* and *Leucaena* have proved beneficial. Bypass protein supplements, where less protein is degraded in the rumen, such as coconut cake, rice bran, cottonseed cake or fish meal have given increased milk production on treated straw. Most of the above, however, involves increased cost to the farmer.

RESEARCH NEEDED

There is potential to increase the coarse fibrous cereal straw even further than the methods described above. This will involve research both at the practical and laboratory levels. Some research needed at the practical level in developing countries include:

- Determine effects of mineral supplementation on the utilization of treated cereal straw.
- Develop methods of recovering and cycling excess ammonia used in the treatment straw.
- Evaluate forms of green foliage as beneficial supplements to treated straw.
- Determine degradability in above methods by use of nylon bags in rumen.

Research needed in the laboratory includes close collaboration between the plant breeder and animal nutritionist to produce cereals with more nutritious residues, and this should receive number one priority. An excellent example of the value of plant breeders and animal nutritionists collaboration comes from the work of Reed *et al.* (1987) working with bird-resistant sorghums. Sorghum is an important crop in subhumid and semiarid tropical developing countries both for the grain for food and the crop residue for cattle. Birds destroy much of the grain and plant breeders have made progress in breeding bird-resistant varieties. The problem is that the leaves of the varieties contain phenolic compounds that are negatively associated with digestibility. If plant breeders were to continue to select for bird-resistant grain varieties only the value of the crop residues would be lowered. There are hopefully varieties that have bird-resistant grain and low phenolic content in the crop residue. As Dr. Jess Reed (1988), animal nutritionist at ILCA, states, "Animal nutritionists have a lot to learn about the extent of genetic variation in straw nutritional quality. We will work closely with plant breeders to make sure that our recommendations for screening methods match the breeder's needs."

More research is needed to determine other factors that control fiber utilization in tropical feeds by ruminants. Factors influencing rates of digestibility, reduction of particle size in the rumen and flow of digesta need continuing study. These can affect palatability which is also in need of further investigation.

SUMMARY

Ruminant animals are a vital part of the agricultural systems in the developing countries and their contributions will continue to be important to the smallholders. One of the truly great phenomena is the fermentation vat carried by ruminants. Because of this, many wasteful products for humans are converted to wholesome food. More research is needed to take full advantage of this phenomenon so that ruminants fed fibrous feeds can contribute even more to the poorest of the poor in the future.

REFERENCES

Bull, L.S. 1979. Sulfur nutrition of ruminants. The 2nd Annual International Mineral Conference. Sponsored by International Minerals and Chemical Corporation, Mundelein, IL, 111-130.

Cunha, T.J. 1982. The animal as a food resource for man. *Proc. 3rd International Conference Goat Prod. and Disease*, Tucson, AR. 1-8.

Cunha, T.J., K.H. Shapiro, J.M. Fransen, H.J. Hodgson, J.E. Johnston, W.H. Morris, R.R. Oltjen, W.R. Pritchard, R.R. Spitzer, and N.L. Van Denmark. 1977. Animal Productivity. Supporting Papers: *World Food and Nutrition Study* 1:141-250. NAS-NRC.

FAO. 1979. *Agriculture: Toward 2000 Conference Proc. 20th Session. Rome, Nov. 10-29, 1979.*

Fitzhugh, H.A., H.J. Hodgson, O.J. Scoville, T.D. Nguyen, and T.C. Byerly. 1978. *The Role of Ruminants in Support of Man.* Winrock International and Livestock Research and Training Center Publication. 136 pp.

Kennedy, P.M., and B.D. Siebert. 1972. The utilization of spear grass (*Heteropogon contortus*). II The influence of sulphur and energy intake and rumen and blood parameters in cattle and sheep. *Aust. J. Agric. Res.* 23:45.

Kahn, A., K.M. Nurazzamal, and C.H. Davis. 1981. Effect of treating paddy straw with ammonia (generated from urea) on the performance of local and crossbred cows. In *Proc. Bangladesh Seminar: Maximum Livestock Production From Minimum Land.* Bangladesh University, Mymensingh. 168-181.

McDowell, R.E. 1979. *Role of Animals in Support of Man.* World Food Issues Series Papers. Cornell University Center for Analysis of World Issues, Ithaca, NY.

McDowell, R.L. 1984. *The Need to Know About Animals.* World Food Issues Series of Papers. Cornell University Center for Analysis of World Issues, Ithaca, NY.

McDowell, R.W. 1988. Delicious, nutritious straw: Breeding plants for higher feed value. In *ILCA Newsletter* 7(1) (January). International Livestock Center for Africa, Addis Ababa, Ethiopia.

Moir, R.J. 1975. The role and requirement for sulfur in ruminant nutrition. In *Sulphur in Australasian Agriculture*, edited by K.D. McLachlan, 109. New York: Sydney University Press.

Nolte, M.E., J.H. Cline, B.A. Dehoritz, S.C. Loerch, and C.F. Parker. 1987. Treatment of wheat straw with alkaline solutions prepared from wood ashes to improve fiber utilization by ruminants. *J. Anim. Sci.* 64:669-677.

Presidential Commission on World Hunger. 1980. *Overcoming World Hunger: The Challenge Ahead.* Report of the Presidential Commission on World Hunger. 734 Jackson Place, Washington, DC.

Preston, T.R., and R.A. Leng, 1985. Matching livestock systems to available feed resources. Unpublished.

Reed, J.D. 1988. Delicious nutritious straw: Breeding plants for higher feed value. *ILCA Newsletter* 7(1) (January). International Livestock Center for Africa, Addis Ababa, Ethiopia.

Reed, J.D., and S. Chater. 1986. The role of secondary plant components in animal nutrition. *ILCA Newsletter* 5(2) (April): 2. International Livestock Center for Africa, Addis Ababa, Ethiopia.

Reed, J.D., A. Tedla, and Y. Kebede. 1987. Phenolics, fibre and fibre digestibility in the crops residue from bird resistant and non-bird resistant sorghum varieties. *J. Sci. Food Agric.* 39:113-121.

Saadullah, M., M. Haque, and F. Dolberg. 1980. Treating rice straw with animal urine. *Tropical Anim. Prod.* 5:273-277.

ISSUES AND OPPORTUNITIES IN DEVELOPMENT AND SUPPORT FUNCTIONS IN ANIMAL AGRICULTURE

J. Henson
Director, International Program Development Office
Washington State University

E. Adams
Vice-Provost and Director of International Programs
Tuskegee University

and N. Raun
Regional Representative
Winrock International Institute for Agricultural Development
Washington, DC

INTRODUCTION

A great deal of information was generated by the individual presentations, small group discussions, as well as from the plenary sessions and discussions during the Symposium. A broad range of impacts, issues, priorities, potentials, activities, and other topics related to animal agriculture, specific technical subjects, and geographic areas of the world were addressed.

During the last sessions of the Symposium, participants defined issues and constraints negatively influencing the contributions of animal agriculture in the developing countries. The participants also identified a number of priorities for potential consideration and action by donors and host country officials. In this paper, we have attempted to summarize the numerous and diverse results and products generated by small groups, plenary presentations, and discussions during the last sessions of the Symposium. Addressed in the following sections of this paper are Symposium proceedings and information generation; the role, current status, and issues of animal agriculture; future trends; and priorities in animal agriculture to the year 2000.

SYMPOSIUM PROCEEDINGS AND INFORMATION GENERATION

A number of excellent presentations on topics directly relevant to animal agriculture and development priorities toward the year 2000 were delivered. A variety of topics including the political and economic context, the contribution of animal agriculture to sustainable development, and the importance of animals and animal products in agricultural production systems and to national economics were addressed. The role of animal agriculture in farm enterprise production, regional and national economies, and in improving environmental quality were also addressed. Donor experiences since 1960 in animal agriculture were examined.

Presentations formed the background for the identification of selected issues in animal agricultural development. The latter was pursued by dividing the approximately 150 participants into small groups to address issues. The small group activities were preceded by individual presentations on technical, infrastructural, environmental/natural resource management, economic, policy, institutional/ organizational, and social issues.

Following the identification of issues, the participants were again divided into small groups and asked to identify and set priorities on a list of opportunities that will significantly eliminate constraints (issues) identified previously and/or develop opportunities toward the future to improve the contributions and sustainability of animal agricultural systems. Small groups were divided according to each of the geographic areas with three major subjects to be addressed within a geographic area. These subjects were: 1) production systems including extensive, integrated crop-livestock, and intensive systems; 2) institution and human resource development; and 3) donors and resources. The small groups reported their findings to the plenary session.

After the Symposium, a previously appointed long-range planning committee met to assess the information presented and to draw conclusions and recommendations. The information given in the following sections draws heavily from the results of the small group activities and the deliberations of the long-range Planning Committee.

ROLES, CURRENT STATUS, AND ISSUES OF ANIMAL AGRICULTURE

Roles

In developing countries, livestock have the roles of products, nonfood products, and services. The estimated annual value of domestic livestock in sub-Saharan Africa is approximately $10 billion; about half is from products (meat, milk, fiber, and skins) and half from nonfood products and services (traction and manure). Livestock provide a large part of the cash income of the rural poor. Increased sales from livestock generate cash income essential to the transition of low resource use agriculture to greater productivity. Because of this linkage, growth in the livestock sector stimulates overall economic activity. Income elasticities of demand for livestock products are generally high. Increases in human population, urbanization, and income levels in developing countries has increased imports of meat and milk by about 10 percent annually. By the year 2000, 44% of the population in developing countries will live in urban centers leading to greatly increased demand for meat and milk. In Asia, demand for animal products is rising approximately 12% per annum. Already animals and animal products contribute about 25% of all agricultural production in developing countries. Over the last decade, the balance in the output of crops and livestock has been relatively stable in developed countries but because of income and urban drive changes in demand, a substantial increase in the contribution of livestock output in the agricultural products continues in developing countries.

Animals utilize crop residues and natural vegetation that has little or no alternative use for humans. In addition, they provide employment, are cost-effective, and provide smallholders and landless with opportunities for generating primary or secondary sources of income and generate capital.

Details concerning the above topics and others related to the actual and potential contributions of livestock to the developing countries are given in the preceding papers. Regardless of the importance of livestock and livestock products to the rural and urban populations of the developing countries, donors including the United States Agency for International Development (USAID) and the World Bank, as examples, are investing few resources in projects directed to improving the performance of the livestock sector and the capacity of its associated institutions. There is a general perception both within and outside USAID, as articulated in the conference, that the Agency is not generally supportive of animal agricultural activities. Perusal of projects currently being implemented by USAID indicates few with a predominant livestock orientation, and those that are appear dominated by animal health and health-related activities. For the World Bank, approximately 5% of its agricultural lending since 1960 has been for livestock activities. The predictions for the next 5 to 10 years indicate a downward trend to as low as 2% of total agricultural lending for livestock activities.

Why is livestock development support not forthcoming? Addressing this question in terms of opportunities and priorities toward the year 2000 is one of the purposes of the Symposium.

The Symposium developed a substantial amount of information related to the actual and potential contribution of animal and animal-related activities to the developing countries. Individuals representing a spectrum of relevant disciplines and backgrounds provided information and identified issues, opportunities, and priorities for animal agriculture in development which is detailed in this summary. Presented papers as well as small working groups addressed selected issues impacting animal agriculture related to technology, infrastructure, environmental/natural resource management, economics, policy, institutional/organizational, and social considerations in Africa, Latin America and the Caribbean, and Asia/Near East. Based upon this information and the products from working groups, opportunities in development and support functions in animal agriculture for recipients and donors were developed and presented during the last plenary session. The long-range Planning Committee met to evaluate and synthesize the issues, opportunities, and priorities originating from the Symposium. Priorities for a strategy for animal agriculture for USAID were developed. Committee members included representatives of USAID, the public and private sectors, and environmental organizations.

In response to the question of why donor-funded livestock and livestock-related projects are not more evident in developing countries, it was agreed that inappropriate policies, particularly exchange rates and commodity price controls, carry much of the blame for the relative failure of livestock production in developing countries. With respect to USAID's portfolio, information presented at this Symposium and from other studies point out causes for this lack of successful performance and suggest alternatives for improvement. Example causes for poor performance of projects are poor project design with unattainable objectives; emphasis on extensive pastoral systems with less emphasis on mixed crop-livestock systems; the negative impact of developed country subsidies which have grossly distorted the world market for livestock and livestock products; and inappropriate or no policies related to land use, pricing, marketing, and credit.

Since the success of livestock-dominated projects is viewed by some as being less than desired, what are the expectations of a donor such as USAID for such projects? The following are some of the general indicators of success for USAID:

- USAID's strategy and priorities for animal agriculture redefined, agreed, and implemented.

- Sustainable development assistance activities in animal agriculture successfully designed, implemented, and recognized as successful.

- Developing country rural income and economies improved as a result of the contribution of animal agriculture.

- Food production increased and human nutrition improved because of successful and sustainable animal agriculture.

- Natural resource base maintained or improved as a result of animal agriculture.

- Increased capacity of public and private institutions in the developing countries to provide and transfer technology, goods, and services to the livestock industry.

- Definition and adoption of policies for investment in the livestock sector, for the production of livestock and livestock products, and for the sustainable management and use of natural resources.

- Decreased importation of livestock products by developing countries.

Microindicators of successful livestock projects will vary according to the specific project design. It was repeatedly indicated during the Symposium that livestock projects have been poorly designed generally with unattainable expectations. Over the years, many lessons have been learned which should enable livestock projects and activities to be designed and implemented more effectively.

Current Status

Based upon these deliberations and discussions of small working groups, in plenary sessions, and by the long-range Planning Committee, the following summarizes the current status of animal agriculture:

1. In developing countries animals are significant contributors to the income, nutrition and well-being of agricultural producers and consumers, and to national economies.

2. Animals, their products, and nonfood contributions must be more fully and effectively utilized so their potential contributions to development can be realized. Returns on donor and host-country investments in sustainable animal agriculture are significant.

3. Currently, non-capital-intensive, small-scale livestock enterprises are a cost-effective method of producing livestock and livestock products, but other alternatives are also effective under given circumstances.

4. Effective animal agriculture, like all agricultural development, requires private sector involvement backed by effective public sector support, research, applied agricultural institutions, education, technology transfer (extension), and supportive infrastructure.

5. Livestock tend to cause less damage to arid and semiarid ecosystems than cultivation, and provide a more stable economic return for the smallholder.

6. Many within and outside USAID have the perception that administrators in USAID are generally not supportive of animal agriculture activities as a part of the Agency's development assistance programs.

7. In the past, development assistance activities emphasizing livestock have frequently not achieved their stated purpose and potential impact. This has been due primarily to inappropriate project design with short time frames; inadequate baseline data; use of concepts and approaches inappropriate to the developing country context; inadequate or ineffective involvement of the individuals and institutions to be served in planning and implementation; overfocus on individual components of multicomponent livestock production systems; inadequate measures for success, especially of nonterminal animal products; and inappropriate recipient country policies, especially those regarding marketing, pricing, and credit.

8. Since animals and animal-related activities are usually integral components of multicomponent agricultural systems, it is necessary with rare exceptions for animal production to be addressed in a system context. Emphasis should be on integrated crop-livestock systems.

9. The natural resource base is the primary foundation which supports agriculture and must be managed and used for sustainability. This is a fundamental consideration for agricultural development, including animal agriculture.

10. There are few developing country institutions that have a growing cadre of trained personnel to plan, implement, and manage animal agriculture activities utilizing the indicated approaches. Livestock, agriculture, animal health, marketing, and natural resource-related activities are commonly located in separate and weakly linked ministries, departments, or institutions. This separation of activities frequently hinders or prevents progress.

11. There is inadequate funding and infrastructure necessary to sustain developing country institutions and activities. These deficiencies frequently prevent the most effective contributions of individuals and institutions to meet development goals.

12. Educational and research institutions and their staffs related to animal agriculture in developing countries must be strengthened and effectively linked to improve animal agriculture production systems.

13. The resources now available for animal agriculture and related activities can be used more effectively through better coordination and communication between and among donors at the Washington, DC and host country levels.

Issues

Issues or constraints to the successful implementation of animal agriculture development activities with resultant impact were addressed by Symposium presenters and participants. These are summarized in three categories: animal agriculture production systems, institutional and human resource development, and donor support and resources. The issues are summarized in the following list. Due to the large number of individual issues defined during the Symposium, the authors have amalgamated related ones for the summary list.

Summary list of issues related to production systems, institutional and human resource development, and donor support and resources

---

PRODUCTION SYSTEMS

- Insufficient support for animal agriculture by donors/USAID.
- Deficiencies in understanding the production system(s) including animals, people, gender roles, environment, and other related factors and in design of projects/interventions according to such systems.
- The natural resource base should be considered as the primary resource with focus on its management, use, and sustainability.
- The role of the producer and consumer in defining needs, approaches, and impact of animal agriculture projects needs greater consideration.
- Projects need to be designed and implemented with achievable purpose and outputs, and which are sustainable and appropriate to the local and national socioeconomic environment, institutions, and producer/consumer components.
- Considerations of policy, marketing, and infrastructure with emphasis on crop-livestock systems and long-term support should be taken into account.
- Linkages between institutions, research on appropriate topics with high potential for adoption and impact, development of implementable technologies, and baseline data collection and analysis are needed.
- Livestock and natural resource sector analyses including land use with development of supportive national strategies and policies are less than desirable.
- Economic analyses of animal agriculture that include traditional and nontraditional measures of animal production systems and impact on local peoples and economies are needed.
- Interface of research, technology transfer, and end-users need attention.
- Private sector involvement should be encouraged.
- Effective management and information systems are essential for project and long-term institutional success.

Summary list of issues related to production systems, institutional and human resource development, and donor support and resources (continued)

PRODUCTION SYSTEMS (continued)

- Integration of crops and livestock requires implementation as well as integration with natural resource management programs.
- Livestock production is needed that is not destructive of the natural resource base and uses crop residues and natural vegetation.
- Feed resources and improved sources of nutrition including plant breeding of food crops, forages, and legumes are needed.
- Potential of local animal and plant varieties and species need to be addressed.
- Integrating subsistence and commercial livestock production offers opportunities.
- Animal health and health delivery systems offer potential.
- Indicators of success of animal agriculture projects need to be defined and incorporated into programs and project design.

INSTITUTIONAL AND HUMAN RESOURCE DEVELOPMENT

- Supportive infrastructure, including extension, credit, policy, marketing, and others needs attention.
- Public and private sector institutions need assistance to address the issues and potential contributions of livestock.
- Host country operational support is frequently insufficient in both the short and long term.
- Trained personnel are frequently lacking in terms of number of staff, type of training, and understanding of production systems. There are limited numbers and involvement of women in agriculture and natural resource development programs.
- Institutional and scientific linkages within a given country, region, and worldwide need to be strengthened to improve access to technology and for staff development.
- Institutional and project managerial capabilities, planning and priority setting, and management and information systems require upgrading.

Summary list of issues related to production systems, institutional and human resource development, and donor support and resources (continued)

DONOR SUPPORT AND RESOURCES

- More coordination among donors is necessary.
- Increase country capacity to manage and utilize resources effectively.
- Inability of host country to leverage donor resources for sustainability and long-term impact is evident.
- Focus on continuity of activities and donor-initiated efforts.
- More effective interface of donor activities is needed with systematic analysis, strategies, and plans by the country within the short and long term.
- Competition of donor-supported activities for limited host country staff has negative impacts.
- Potential high return from investment in livestock and animal health activities is not being realized.
- Effective working relationship between public and private sectors needs strengthening.

FUTURE TRENDS IN ANIMAL AGRICULTURE

Some suggested future trends that will likely impact donor-supported development assistance related to animal agriculture follow:

1. The availability of funds for development assistance from USAID and other donors will likely decline.

2. There will be a greater reliance on networks and linkages involving International Agricultural Research Centers (IARCs), Collaborative Research Support Projects (CRSPs), universities, private voluntary organizations (PVOs), Peace Corps, and the private sector in the research/transfer of the technology continuum.

3. Increased attention will likely be given to ruminant species by the international donor community and host countries. Needs of the poultry and swine industries will likely be met principally by the private sector.

4. Primary emphasis will likely be placed on integrated crop-livestock systems since most crops and livestock are produced in these systems.

5. Increased attention will be given to improving the integration of natural resource management with agricultural production and to the sustainable management and use of natural resources.

6. Closer linkages will evolve between IARCs, National Agricultural Research organizations (NARs), donor-supported programs, U.S. universities, and PVOs in research/transfer of technology programs in host countries.

PRIORITIES IN ANIMAL AGRICULTURE TO THE YEAR 2000

An overriding point made by the participants was the current and potential contributions of animal agriculture to incomes, nutrition, and economies in the developing countries. It was further indicated that the potentials of animal agriculture are not being realized because of a number of factors including a low level of donor support. It has been shown, however, that certain aspects of animal agricultural development activities such as animal health have been successful and have provided acceptable returns on investment. Other animal agriculture-related activities have similar potential for impact. Information developed by the participants addressing the Africa, Asia/Near East, and Latin American regions and specific technical and nontechnical topics indicated that there are a number of generic issues and potentials that cross regional and national boundaries. There are, however, issues and opportunities which are regionally, nationally, and locally specific.

The general findings of the Symposium suggest that isolated technologies in and of themselves will not bring about the desired results from development activities in animal agriculture. The participants emphasized there must be an effective interface among technology, policy, and public and private institutions and human resource development. Management, priority setting, sustainability of long-term support, and sustaining the natural resource base were all emphasized. Furthermore, a great deal of experience has been gained and lessons learned from these experiences in terms of specific planning and implementation of animal agricultural activities, but details about these experiences have not been brought together in a usable form. However, some have been included in papers, reports, and other documentation by USAID and donors. Examples from USAID include: the May, 1985 ARD Report on "The African Livestock Sub-sector: USAID Project Experience;" the African Livestock Development Assistance paper published in December, 1982; and a panel report entitled, "Suggestions for the Improvement of Rangeland Livestock Projects in Africa" published in 1985. These and other documents provide useful information related to animal agriculture in development assistance.

In the past, emphasis has been on extensive livestock production, at least in the African context. Few resources have addressed mixed crop-livestock production systems which have been indicated in several documents and discussions as having a higher priority and a higher potential for success than extensive systems. The participants emphasized the necessity of addressing livestock participation and contribution to mixed crop-livestock systems which utilize not only natural vegetation, but crop by-products and related feed and nutrition sources. The development of forage and improvement of pasture and related activities are also a consideration. The importance of small stock such as poultry, rabbits, sheep, and goats also need to be taken into account, especially as these relate and contribute to small farm income.

The overall conclusions drawn from the meeting are that: a) livestock are now contributing and can further contribute to the developing countries; b) experience and lessons learned are currently available for more effective planning and implementation of livestock-related activities; and c) donors should consider supporting livestock as subcomponents of multicomponent projects. Based upon the information generated during the Symposium the following priorities were identified:

1. Animal agriculture projects, programs, and project components should be given priority and support by USAID based upon their potential impact and contributions to economic development. These activities should consider animal agriculture as an integral component of agricultural production systems and should support the efficient and sustained production of livestock/products without damaging the underlying resource base.

2. Develop and/or update an "Animals in Agriculture Strategy" for USAID in general, and for the Africa, Latin America, and Asia/Near East Bureaus in particular, including a protocol for assisting in planning and/or incorporation of animal-related activities into the design of new projects or extensions of current projects. Use information generated from the Symposium, USAID documentation, previous USAID-funded projects, donors, and other sources.

3. USAID support should continue to emphasize the strengthening of developing country animal agriculture research capabilities and the long-term participation of the IARCs, Small Ruminant Collaborative Research Support Projects (SR/CRSPs), U.S. universities, and other institutions with national agricultural research organizations.

4. Institutional and human resource development should be a high priority with emphasis on participant training and the development of host country institutional capacities to educate agriculturalists, to conduct research, and to transfer technology. Technical, planning, and managerial capabilities should be emphasized.

5. Project and/or project component design and implementation should consider the needs, socioeconomic environment, and participation of producers and consumers; be based upon appropriate and sometimes nontraditional indicators of impact and success; utilize an interdisciplinary team approach to planning and problem solving; incorporate individuals knowledgeable about animal agriculture in planning, sector analysis, policy analysis, and related activities; define attainable purpose and outputs; and stress policy and infrastructure as well as technology.

6. Subject matter priorities:

   a. Production systems for ruminants in crop-livestock systems. Emphasis should be placed on crop-livestock synergisms and production systems; the role of livestock in increasing income, creating employment, providing cash flow, reducing risks, and in increasing food production; and agricultural sector policies including marketing, credit, pricing, and land use. Priority technical components of these systems would include feeding systems, animal health/vaccines, genetic disease tolerance/resistance, small ruminants, and forages.

b. Production systems for ruminants in fragile lands (arid, acid-soil, and hilly regions). Emphasis should be on the utilization of ruminants to harvest and transform pastures and forages into products that are useful to man without damaging the underlying resource base. Priority components would include feeding systems, animal health/ vaccines, breed disease tolerance/resistance, and small ruminants. Policies including land use, marketing and credit should be included.

PRIORITIES FOR ANIMAL AGRICULTURE

The following have been identified as priorities for animal agriculture by the participants and the long-range Planning Committee of the Animal Agriculture Symposium. It is intended that these priorities will provide guidance and information of value to Missions and the Agency as a whole in planning programs and projects.

1. Support animal agriculture projects and programs based upon their significant present and future contributions to economic development.

2. Consider animal agriculture as an integral component of projects and activities in sustainable management and use of natural resources.

3. In more intensive animal agriculture systems, emphasize crop-livestock complementarities; agricultural sector policies including markets which promote livestock or mixed crop-livestock enterprises for income, for local consumption and/or export; and technical and management interventions that support sustainable increases in productivity and efficiency.

4. In the pastoral or more extensive animal agriculture systems, include land use planning and policies as complementarities of crop-livestock systems and in the sustainable use of natural vegetation. Strengthen agricultural sector policy and marketing to stimulate offtake in terms of quantity and quality of animals and animal products for local consumption and export. Stress technical and management interventions that leverage and facilitate improved productivity to increase incomes, food availability and consumption, and the well-being of producers.

5. To optimize the contributions of animal agriculture to the economies of the developing countries, emphasize the coordination and management of programs and resources within and among host country and donor organizations. This requires improving the technical capability and managerial performance of these organizations and their human resources through institutional development, training, and related activities.

6. Within the context of the above items, focus on the development, transfer and adoption of specific technologies and/or policies pertinent to given host country situations to include economics, policy, nutrition, animal health, supportive infrastructure, management, and others as appropriate.

Session IV	**Selected Issues in Animal Agricultural Development**	
	Moderator:	P. Brumby
	Rapporteur:	G. Garbinsky
	Technical	
	Speakers:	R. McDowell, A. Pope
	Infrastructural	
	Speaker:	D. Stryker
	Environmental/Natural Resource Management	
	Speaker:	T. Box
Session V	**Selected Issues in Animal Agricultural Development**	
	Moderator:	H. Knipscheer
	Rapporteur:	V. Cusumano
	Economic	
	Speaker:	J. DeBoer
	Policy	
	Speaker:	J. Maner
	Social	
	Speaker:	C.J. Weidemann
Session VI	**Opportunities in Development and Support Functions for Recipients and Donors**	
	Moderator:	N. Raun
	Rapporteur:	D. Luchsinger
	Speakers:	J. Henson, E. Adams
Final Remarks	D. Acker	

SYMPOSIUM AGENDA

Introduction and Overview

N.C. Brady
W. Furtick

Session I **Keynote: Political and Economic Context of Animal Agriculture**

Moderator: J. DeBoer
Rapporteur: J. Dickey
Speaker: J. Mellor
Discussants: M. Avila, J. Simpson

Session II **The Contribution of Animal Agriculture to Sustainable Development**

Moderator: J. Simpson
Rapporteur: S. Berwick

Importance of Animal Agriculture in Production Systems

Speakers: J. McIntire, B. Gunawan

Contribution of Animal Agriculture to National Economies: Some Examples

Speaker: L. Jarvis

Role of Animal Agriculture in Farm Enterprises/Household Production and Linkage to Regional and National Economies

Speaker: B. Quijandria

Role of Animal Agriculture in Improving Environmental Quality

Speaker: A. Florez

Session III **Examination of Donor Experience Since 1960**

Moderator: M. Yudelman
Rapporteur: D. Dwyer
Speaker: P. Brumby
Discussants: M. Avila, M. Ben Ali

Session IV **Selected Issues in Animal Agricultural Development**

Moderator: P. Brumby
Rapporteur: G. Garbinsky

Technical
Speakers: R. McDowell, A. Pope

Infrastructural
Speaker: D. Stryker

Environmental/Natural Resource Management
Speaker: T. Box

Session V **Selected Issues in Animal Agricultural Development**

Moderator: H. Knipscheer
Rapporteur: V. Cusumano

Economic
Speaker: J. DeBoer

Policy
Speaker: J. Maner

Social
Speaker: C.J. Weidemann

Session VI **Opportunities in Development and Support Functions for Recipients and Donors**

Moderator: N. Raun
Rapporteur: D. Luchsinger
Speakers: J. Henson, E. Adams

Final Remarks D. Acker

LIST OF PARTICIPANTS

Youssouf Abdel-Jelil
2745 Ordway St., NW, #3
Washington, DC 20008
202/363-7390

Larry Abel
Agriculture Officer
AFR/TR/ANR
Room 2884, NS
Agency for International Development
Washington, DC 20523

Arch F. Alexander, D.V.M.
Department of Pathology
Colorado State University
Fort Collins, CO 80523

Yvonne Andualem
Technical Assistance Officer
USDA/OICD/TAD/AFR
Room 227, McGregor Bldg.
Washington, DC 20250-4300
202/653-7335

J. Lawrence Apple
Office of International Programs
North Carolina State University
Box 7112
Raleigh, NC 27695
919/737-2665

Edgar J. Ariza-Nino
Principal Associate
Robert R. Nathan Associates
1301 Pennsylvania Ave., NW
Washington, DC 20004
202/393-2700

Joan Atherton
PPC/PDPR/RP
Room 3893E, NS
Agency for International Development
Washington, DC 20523

Frank Baker
Winrock International
Route 3
Morrilton, AR 72110
501/727-5435

David D. Bathrick
Director
S&T/AGR
Room 409, SA-18
Agency for International Development
Washington, DC 20523
703/875-4300

Rob Bertram
S&T/AGR
Room 513, SA-18
Agency for International Development
Washington, DC 20523

Robert W. Blake
Associate Professor
International Agriculture and
Animal Science
Department of Animal Science
Cornell University
131 Morrison Hall
Ithaca, NY 14853
607/255-2858

Andrea Y. Blumberg
ANE/TR/ARD
Room 4400, NS
Agency for International Development
Washington, DC 20523

Louis J. Boyd
Coordinator, International Agriculture
College of Agriculture
University of Georgia
Athens, GA 30602
404/542-3390

Eric G. Bradford
Profesor of Animal Science
Department of Animal Science
University of California
Davis, CA 95616
916/752-7602

Fred Bryant
Department of Range and Wildlife Management
Texas Tech University
Lubbock, TX 79409

Lee Bulla
Dean of College of Agriculture
University of Wyoming
PO Box 3354
University Station
Laramie, WY 82071
307/766-4133

Peter J. Burfening
Professor of Animal Science
Montana State University
Bozeman, MT 59717
406/994-5573

Helaine Burstein
c/o Animal Science Department
North Carolina State University
Box 7621
Raleigh NC 27695-7621

Sandra Callier
Project Management Specialist
USDA/OICD/TAD/DPMC
Room 207, McGregor Bldg.
Washington, DC 20250-4300
202/653-7402

John R. Campbell
Dean, College of Agriculture
University of Illinois
101 Mumford Hall, 1301 Gregory Dr.
Urbana, IL 61801
217/333-0460

Gerald A. Cashion
Social Science Advisor
AFR/DP
Room 3913
Agency for International Development
Washington, DC 20523
202/647-2964

Dave Chantry
Pfizer International, Inc.
Agricultural Products Division
235 E 42nd St.
New York, NY 10017
212/573-2864

Joel I. Cohen
Biotechnology Specialist
S&T/AGR
Agency for International Development
Washington, DC 20523
703/875-4240

Joseph H. Conrad
Professor, International Animal Science
University of Florida
Gainesville, FL 32611
904/392-2180

Andrew D. Cook
Livestock Marketing Economist
Project Elevage Integre
BP 10848
Niamey, Niger
or
Tufts University (Niger Project)
Medford, MA 02155

Thomas W. Crawford
Agriculture Officer
LAC/DR/RD
Room 2242, NS
Agency for International Development
Washington, DC 20523
202/647-8078

E.P. Cunningham
Visiting Professor
Economic Development Institute
The World Bank
1818 H St., NW
Washington, DC 20433

John Diehl
USAID/Guatemala
APO Miami 34024

Stanley L. Diesch, D.V.M.
Professor
424 Veterinary Teaching Hospitals
University of Minnesota
1365 Gorner Ave.
St. Paul, MN 55108
612/625-7296

Jack Doyle, D.V.M.
Director of Research
ICRAD
PO Box 30709
Nairobi, Kenya
254-2-592311

Robert H. Dunlop, D.V.M.
Dean, College of Veterinary Medicine
University of Minnesota
1365 Gorner Ave.
St. Paul, MN 55108
612/624-9227

David P. Dupras
Project Supervisor
Chemonics International
2000 M St., NW, Suite 200
Washington, DC 20036
202/466-5340

Clive A. Edwards
Chairman and Professor
Department of Entomology
Ohio State University
1735 Neil Ave.
Columbus, OH 43210
614/292-8209

Barbara Ellington-Banks
Agriculture Development Officer
USAID/Belize
Dept. of State
Washington, DC 20520-3050

Arthur Felix
Associate Professor
Dept. of Food Science and
Animal Industry
Alabama A&M University
PO Box 264
Normal, (Huntsville) AL 35762
205/859-7234

Don Ferguson
USDA/OICD/TAD
Room 333, McGregor Bldg.
Washington, DC 20250-4300
202/653-5457

Larbi Firdawcy
IAV Hassan II
BP 6202
Rabat Instituts, Morocco

Ian E. Fraser
Agribusiness Consultant
CIAT International
1331 H St., NW
Washington, DC 20005
202/879-2931

Frank Frazier
Executive Vice President
American Society of Agricultural
Consultants
8301 Greensboro Dr., Suite 260
McLean, VA 22102
703/356-2455

Victor G. Ganoza
Team Leader-Clusa/A.I.D.
Dairy Development Project
USAID/Guatemala
Department of State
Washington, DC 20520-3190
32-08-08

Vera Gathright
IFAD
c/o UN Information Office
1889 F St., NW
Washington, DC 20006

Jere Lee Gilles
Department of Rural Sociology
University of Missouri, Columbia
Sociology Bldg.
Columbia, MO 65211
314/882-3791

Dick Gray
PO Box 33414
Raleigh, NC 27636

Peter Gregory
Director of Research
International Potato Center (CIP)
Apartado 5969
Lima, Perú
51-14-366920

Bill Gschwend
Director, LA/C
A. T. International
1331 H St., NW
Washington, DC 20005
202/879-2900

Richard L. Guthrie
International Agriculture Programs
Auburn University
Auburn, AL 36849
205/826-4608

Peter C. Hall
Chief Operations Officer
Resources Development Foundation
1920 N St., Suite 400
Washington, DC 20036
202/466-2177

Karunadasa Haputantri
Hubert H. Humphrey Fellow
c/o Pierrette Countryman
OICD/USDA
Washington, DC 20250-4300
202/653-7401

Gilford Harrison
Division Manager, Mexico & S. America
American Soybean Association
777 Craig Rd., PO Box 27300
St. Louis, MO 63141
314/432-1600

Percy Hawkes, D.V.M.
Senior Staff Veterinarian
USDA/APHIS
International Programs
Room 868, Federal Bldg.
Hyattsville, MD 20782
301/436-8285

Bert W. Hawkins
Spec. Assistant to the Sec. of Agriculture
Detail to OICD/OA/USDA
Room 317, McGregor Bldg.
Washington, DC 20250-4300
202/653-9314

William D. Hohenboken
Professor of Animal Science
VPI&SU
Blacksburg, VA 24060
703/961-6763

E. Jane Homan, D.V.M.
Assistant Research Specialist
International Agriculture Program
University of Wisconsin, Madison
240 Agriculture Hall, 1450 Linder Dr.
Madison, WI 53706
608/262-4874

Harvey Hortik
S&T/AGR
Room 420, SA-18
Agency for International Development
Washington, DC 20523
703/875-4304

Robert E. Hudgens
Program Officer-Agricultural Systems
Winrock Internat'l Institute for Ag. Development
Rt. 3
Morrilton, AR 72110
501/727-5435

Robert D. Jackson
USDA
Room 364, McGregor Bldg.
Washington, DC 20250-4300
202/653-7520

Tony Jilek
University of Wisconsin, River Falls
201 Ag. Science Bldg.
River Falls, WI 54022
715/425-3702

William Frederick Johnson
International Research Programs Officer
BIFAD Staff
Agency for International Development
Washington, DC 20523
202/647-8532

William Johnson
Animal Science Department
North Carolina State University
Box 7621
Raleigh, NC 27695-7621

Ryohei Kada
Associate Professor
Dept. of Agricultural & Forestry Economics
Faculty of Agriculture
Kyoto University
Kyoto 606 Japan
075/751-2111 ext. 6203

David Kiesling
Department of Agriculture
Lincoln University
Box 29
Jefferson City, MO 65102

Ronald H. Kohlmeier
Technical Director, Animal Nutrition
American Soybean Association
777 Craig Rd., PO Box 27300
St. Louis, MO 63141
314/432-1600

Odin Knudsen
The World Bank
1818 H St., NW
Room J2081
Washington, DC 20433
202/473-8508

Nels M. Konnerup, D.V.M.
Veterinary Livestock Consultant
Bova International/Embryo Transfer
8500 Cedarhome Dr.
Stanwood, WA 98292
202/387-0478 or 629-4551

Althaea Langston
USDA/APHIS
6505 Belcrest Rd.
Room 406
Hyattsville, MD 20782

Martha W. Lewis
Director, Women in Development
Partners of the Americas
1424 K St., NW
Washington DC 20005
202/628-3300

Christopher D. Lu
Director
American Institute for Goat Research
PO Box 730
Langston, OK 75050
405/466-3836

Steven D. Lukefahr
International Small Livestock Research Center
Alabama A & M University
PO Box 264
Normal, AL 35762
205/859-7488

Domingo Martinez
University of Missouri-Columbia
318 Mumford Hall
Columbia, MO 65211

Constance M. McCorkle
Research Assistant Professor
Dept. of Rural Sociology
University of Missouri
Columbia, MO 65211
314/882-6632

Scott J. McCormick
Land & Water Resources Specialist
Associates in Rural Development
110 Main St., PO Box 1397
Burlington, VT 05402
802/658-3890

Kirkland E. Mellad
Professor & Chairman
Dept. of Animal Science
Southern University
PO Box 9509
Baton Rouge, LA 70813
504/771-3111

George H. Meyers
Managing Director
International Technical Programs
Holstein Association
One Holstein Pl.
Brattleboro, VT 05301
802/254-4551

Wendell E. Morse, Jr.
BIFAD
Room 5314A
Agency for International Development
Washington, DC 20523
202/647-8408

Kathryn H. Nepote, D.V.M.
Director, Laboratory Animal Care
University of Maryland
CARF, Bldg. 087
College Park, MD 20742
301/454-4668

Michael F. Nolan
Associate Dean
University of Missouri
2-6a Agriculture Bldg.
Columbia, MO 65211
314/882-2745

Paul Novick
Agriculture Development Officer
ANE/TR
Room 4440, NS
Agency for International Development
Washington, DC 20523

Howard H. Olson
Professor, Dairy Science
Southern Illinois University
Carbondale, IL 62901
618/453-2329

Jim Oxley
Program Director
Small Ruminant CRSP
University of California-Davis
Davis, CA 95616

Gregory K. Perrier
Dept. of Range Science
UMC 5230
Utah State University
Logan, UT 84322
801/750-1585

Kevin Pond
Department of Animal Science
North Carolina State University
Box 7621
Raleigh, NC 27695-7621
919/737-2766

Freddie L. Richards
Director, International Programs
Prairie View A&M University
PO Box 608
Prairie View, TX 77446-0608

David Robertshaw
Professor and Chairman
Dept. of Physiology
VRT 725
Cornell University
Ithaca, NY 14853-6401
607/253-3854

Michael W. Sands
Director, Agricultural Sciences
Rodale International
222 Main St.
Emmaus, PA 18098
215/967-5171

Tjaart W. Schillhorn-Van Veen, D.V.M.
Professor
Michigan State University
A-12 Veterinary Clinical Center
East Lansing, MI 48824
517/353-6489

Mohamed Sedrati
USAID/Rabat
c/o American Embassy
Rabat, Morocco
212-7-622-6590112127 ext 510/511

Carlos Seré
Economist
Tropical Pastures Program
C.I.A.T - A.A. 6713
Cali, Colombia
57-3-675050

Steven H. Sharrow
Professor
Dept. of Rangeland Resources
Oregon State University
Corvallis, OR 97331

George P. Shibley
Senior Staff Microbiologist
USDA/APHIS
Room 833, Federal Bldg.
6505 Belcrest Rd.
Hyattsville, MD 20782
301/436-8674

Poul A. Sihm
Senior Livestock Specialist
The World Bank
11677 North Shore Dr.
Reston, VA 22090
202/473-4115

Balmore Silva, D.V.M.
Principal Veterinary Officer
Ministry of Agriculture
Government of Belize
Belize City, Belize

Ocleris Simpson
Dean for Research and Extension
Langston University
PO Box 730
Langston, OK 73050
405/466-3836

Chip Stem, D.V.M.
Head, International Veterinary Medicine
Tufts University
200 Westboro Rd.
N. Grafton, MA 01536
508/865-1764

Dr. Louis L. Suchet
Professor of Animal Science
Office of International Programs
Tuskegee University
Tuskegee, AL 36088

John Swallow
Room 5881, NS
Agency for International Development
Washington, DC 20523
202/647-9660

Helen A. Swartz
State Sheep, Goat & Small Livestock Specialist
Lincoln University
900 Moreau Dr.
Jefferson City, MO 65101
314/681-5533

Thian H. Teh
Research Leader
International Dairy Goat Research Center
Prairie View A&M University
PO Box U
Prairie View, TX 77446-0608
409/857-3916

Javier Trujillo
Centro de Entomología Y Acarología
Colegio de Postgraduados
56230 Chapingo
Mexico
52-595-42873

Patricia J. Vondal
Consultant
3610 Van Ness St., NW
Washington, DC 20008
202/362-9319

Henry Waidlick
Ultimate Conceptions
Mineral Rd.
Millers Falls, MA 01349
413/659-3497

Jake Walter
Vice President
American Breeders Service
Box 459
Deforest, WI 53532
608/846-3721

Terence O. Wheeler
Consulting Range/Livestock Specialist
Arizona Ranch Management
Center for Holistic Resource Management
PO Box 2792
Globe, AZ 85502
602/425-3017

Walter F. Williams
Professor of Animal Sciences & Acting Head
Central Maryland Research & Education Center
Route 2, Box 274
Laurel, MD 20708
301/982-0094

Yvonne L. Williams
Vice President for Federal and International Relations
Tuskegee University
11 Dupont Circle, NW, Suite 490
Washington, DC 20036
202/797-3670

Thomas M. Yuill, D.V.M.
Associate Dean
School of Veterinary Medicine
University of Wisconsin
2015 Linden Dr. West
Madison, WI 53706
608/263-1008

Jose A. Zaglul
Head, Tropical Livestock Area
CATIE
Turrialba, Costa Rica, C.A.
506/56-64-18

Bob Zimbelman
Executive Vice President
American Society of Animal Science
9650 Rockville Pike
Bethesda, MD 20814

CONSULTING GROUP

Chair:

Dr. William Furtick
Director, Directorate of Food and Agriculture
S&T/FA
Room 513, SA-18
Agency for International Development
Washington, DC 20523

Members:

Dr. Peter Brumby
Senior Livestock Advisor
The World Bank/PPR
Room J2251
1818 H St., NW
Washington, DC 20433
202/473-7577

Dr. Ralph W. Cummings, Sr.
812 Rosemont Ave.
Raleigh, NC 27607
919/833-1863

Dr. R.E. McDowell
Professor
North Carolina State University
Department of Animal Science
PO Box 7621
Raleigh, NC 27695
919/737-2766

Dr. John Mellor
Director
IFPRI
1776 Massachusetts Ave., NW
Washington, DC 20036
202/862-5633

Dr. Arthur L. Pope
Professor
University of Wisconsin
256 Animal Sciences Bldg.
Madison, WI 53706
608/263-4300

Dr. William R. Pritchard
Professor
School of Veterinary Medicine
University of California, Davis
Davis, CA 95616

Dr. Ned S. Raun
Regional Representative/Washington
Winrock International
1611 N. Kent St.
Arlington, VA 22209
703/525-9430

Mr. Darwin Stolte
President
U.S. Feed Grains Council
1400 K St., NW
Suite 1200
Washington, DC 20005

Dr. Kenneth Turk
Dean Emeritus
Dept. of Animal Science
Cornell University
Ithaca, NY 14850

PLANNING COMMITTEE

Joyce Turk (**Chair**)
S&T/AGR/AP
Room 420-G, SA-18
Agency for International Development
Washington, DC 20523

Raul Hinojosa (**Co-chair**)
LAC/DR
Room 2242, NS
Agency for International Development
Washington, DC 20523

Larry Able
AFR/TR/ARD
Room 2941, NS
Agency for International Development
Washington, DC 20523

Joan Atherton
PPC/PDPR/RP
Room 3893E, NS
Agency for International Development
Washington, DC 20523

Gerald A. Cashion
AFR/DP
Room 3913
Agency for International Development
Washington, DC 20523

John Grayzel
S&T/RD
Room 2941, NS
Agency for International Development
Washington, DC 20523

Larry Harms
USAID/Port-au-Prince
Agency for International Development
Washington, DC 20523-3400

Paul Novick
ANE/TR
Room 4440, NS
Agency for International Development
Washington, DC 20523

Wilbur Scarborough
USAID/Jakarta
Box 4
APO San Francisco 96356

AD HOC COMMITTEE ON AGRICULTURE SUSTAINABILITY

Ambassador Robert O. Blake
Senior Fellow
International Institute for Environment
and Development
1717 Massachusetts Ave., NW
Suite 302
Washington, DC 20036

Dr. Stephen Berwick
Chief Scientist
International Institute for Environment
and Development
1717 Massachusetts Ave., NW
Suite 302
Washington, DC 20036
202/462-0900

Dr. Arturo Florez
Co-director of National Research Division
INIAA
Coricancha 595
C.C. Monterrico
Surco Lima, 33 - Perú
51-14-35211

Dr. William Furtick
Agency Director for Food and Agriculture
S&T/FA
Room 513, SA-18
Agency for International Development
Washington, DC 20523
703/875-4002

Mr. Greg Garbinsky
Program Leader
USDA/OICD/TAD/WWP
Room 228, McGregor Bldg.
Washington, DC 20250-4300
202/653-7365

Dr. Bennie Gunawan
Director
Research Institute for Animal Production
Balai Penelitian Ternak
PO Box 123
Bogor, Indonesia 16001
62-251-27150

Dr. James B. Henson
Director, IPDO
Washington State University
328 French Admin
Pullman, WA 99164-1034
509/335-2541

Dr. Lovell Jarvis
Department of Agricultural Economics
201 Boorhies Hall
University of California
Davis, CA 95616
916/752-7221 or 1515

Dr. Donald Luchsinger
Animal Health Advisor
S&T/AGR/AI
Room 413F, SA-18
Agency for International Development
Washington, DC 20523
703/875-4162

Dr. Jerome Maner
Regional Director/Latin America and Caribbean
Winrock International
Route 3
Morrilton, AK 72110
501/727-5435

Dr. R.E. McDowell
Professor
North Carolina State University
Department of Animal Science
PO Box 7621
Raleigh, NC 27695
919/737-2766

Dr. John McIntire
International Livestock Centre for Africa
PO Box 5689
Addis Ababa, Ethiopia
251-1-183215

Dr. John Mellor
Director
IFPRI
1776 Massachusetts Ave., NW
Washington, DC 20036
202/862-5633

Dr. Michael Nolan
Associate Dean
University of Missouri
2-69 Agriculture Bldg.
Columbia, MO 65211
314/882-2745

PROGRAM OFFICIALS

Dr. Duane Acker
Assistant to the Administrator
for Food and Agriculture
Room 5883, NS
Agency for International Development
Washington, DC 20523
202/647-9660

Dr. Eugene W. Adams
Vice Provost and Director
Office of International Programs
Tuskegee University
Kresge Center, Room 219
Tuskegee, AL 36075
205/727-8953

Dr. Marcelino Avila
Senior Scientist
ICRAF
Box 30677
Nairobi, Kenya
254-2-521450

Mr. Mohamed Ben Ali
Agronomist
G Rue Zaghouani
Zaghouan - 1100
Tunisia
02-76404

Dr. Stephen Berwick
Chief Scientist
IIED
1717 Massachusetts Ave., NW
Suite 302
Washington, DC 20036
202/462-0900

Dr. Thadis W. Box
Professor and Dean
College of Natural Resources
Utah State University
Logan, UT 84322-5200
801/750-2445

Dr. Nyle C. Brady
Senior Assistant Administrator
for Science and Technology
S&T/SAA
Room 4942, NS
Agency for International Development
Washington, DC 20523
202/647-1827

Dr. Peter Brumby
Senior Livestock Advisor
The World Bank/PPR
Room J2251
1818 H St., NW
Washington, DC 20433
202/473-7577

Dr. Vince Cusumano
Chief
S&T/EPP
Room 403C, SA-18
Agency for International Development
Washington, DC 20523
703/875-4218

Dr. John DeBoer
Chief of Party
Nepal ARP
PO Box 1336
Kathmandu, Nepal
160-977-522795 or 523269

Dr. James R. Dickey
Private Consultant
House 47, Rd 23
Banani, Dhaka 12, Bangladesh
880-60-69-60

Dr. Don D. Dwyer
Professor (Adjunct)
New Mexico State University
Las Cruces, NM 88003
505/525-3610

Dr. Arturo Florez
Co-director of National Research Division
INIAA
Coricancha 595
C.C. Monterrico
Surco Lima, 33 - Perú
51-14-35211

Dr. William Furtick
Agency Director for Food and Agriculture
S&T/FA
Room 513, SA-18
Agency for International Development
Washington, DC 20523
703/875-4002

Mr. Greg Garbinsky
Program Leader
USDA/OICD/TAD/WWP
Room 228, McGregor Bldg.
Washington, DC 20250-4300
202/653-7365

Dr. Bennie Gunawan
Director
Research Institute for Animal Production
Balai Penelitian Ternak
PO Box 123
Bogor, Indonesia 16001
62-251-27150

Dr. James B. Henson
Director, IPDO
Washington State University
328 French Admin
Pullman, WA 99164-1034
509/335-2541

Dr. Lovell Jarvis
Department of Agricultural Economics
201 Boorhies Hall
University of California
Davis, CA 95616
916/752-7221 or 1515

Dr. Donald Luchsinger
Animal Health Advisor
S&T/AGR/AP
Room 413F, SA-18
Agency for International Development
Washington, DC 20523
703/875-4162

Dr. Jerome Maner
Regional Director/Latin America and Caribbean
Winrock International
Route 3
Morrilton, AK 72110
501/727-5435

Dr. R.E. McDowell
Professor
North Carolina State University
Department of Animal Science
PO Box 7621
Raleigh, NC 27695
919/737-2766

Dr. John McIntire
International Livestock Centre for Africa
PO Box 5689
Addis Ababa, Ethiopia
251-1-183215

Dr. John Mellor
Director
IFPRI
1776 Massachusetts Ave., NW
Washington, DC 20036
202/862-5633

Dr. Michael Nolan
Associate Dean
University of Missouri
2-69 Agriculture Bldg.
Columbia, MO 65211
314/882-2745

Dr. John Pino
Senior Research Fellow
National Academy of Sciences (HA394)
2101 Constitution Ave., NW
Washington, DC 20418
202/334-3072

Dr. Arthur L. Pope
Professor
University of Wisconsin
256 Animal Sciences Bldg.
Madison, WI 53706
608/263-4300

Dr. Benjamin Quijandria
Executive Director
Centro de Estudios Y de Desarrollo
Agrario del Perú
Capac Yupanqui 2454-Lince
Lima, Peru Lima 14
51-14-222956 or 224951

Dr. Ned S. Raun
Regional Representative/Washington
Winrock International
1611 N. Kent St.
Arlington, VA 22209
703/525-9430

Dr. James Simpson
Professor
McCarthy Hall, Room 1113
University of Florida
Gainesville, FL 32611
904/392-1854

Dr. Dirck Stryker
Professor
Fletcher School of Law and Diplomacy
Tufts University
Medford, MA 02155
617/625-1840

Ms. Joyce Turk
Livestock Advisor
S&T/AGR
Room 420G, SA-18
Agency for International Development
Washington, DC 20523
703/875-4081

Dr. Celia J. Weidemann
Private Consultant
2607 N. 24th St.
Arlington, VA 22207
703/522-3075

Mr. Richard Wheeler
Agriculture Consultant
c/o E.P.I.
6708 Whittier Ave.
McLean, VA 22101
703/734-8787

Ambassador Alan Woods
Administrator
Agency for International Development
320 21st St., NW
Room 5942
Washington, DC 20523
202/647-9620

Dr. Montegue Yudelman
Private Consultant
3108 Garfield St., NW
Washington, DC 20008
202/965-4642