

Livestock development strategies for low income countries - Proceedings of the joint FAO/ILRI roundtable on livestock development strategies for low income countries



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Abstract

This volume contains an executive summary of papers and the discussions on them as well as the reports of working groups and the recommendations of the Roundtable on Livestock Development Strategies for Low Income Countries. In addition to the executive summary there is a Keynote paper and two other background papers, two papers on issues, constraints and opportunities for livestock development and five papers on options for increasing livestock's contribution from the major production systems. The volume also contains reports of all the discussions and summarized reports of the working groups that were convened for sub-Saharan Africa and West Asia and North Africa, Asia, and Latin America and the Caribbean. It is completed by a short report of the discussion at the final plenary session, the closing peroration and the recommendations of the Roundtable.

Keywords

/Livestock/ /development/ /research/ /structural adjustment/ /policy/ /production/ /low income countries/ /developing countries/ /sub-Saharan Africa/ /West Asia/ /North Africa/ /Asia/ /Latin America/ /Caribbean/

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Livestock in low income countries

Between 1960 and 1990 the world's human population increased by 75 per cent from 3.1 billion to 5.4 billion but developing country populations increased by 97 per cent from 2.1 billion to more than 4.1 billion. In the late 1970s, 45 developing countries were unable to assure adequate food energy needs of 2200 calories per person per day for their populations and 25 of these countries still had food deficits the late 1980s. Some 800 million people now suffer from malnutrition and hunger, not only due to low production and unequal distribution but also because poor people lack the income to acquire adequate quantities and qualities of food. The world population will increase from 5.4 billion in 1990 to about 7.2 billion in 2010. The increase will be mainly in the developing countries and in urban areas and will have major effects on patterns of food production, marketing and consumption.

Developing countries have nearly two thirds of the world's livestock but produce less than a third of the world's meat and a fifth of its milk. Low output is due to low offtake rates and low yields per animal. Beef and veal output per head of cattle in North America is 281 kg whereas yields in Africa and Asia are about half of this. In South America beef and veal output per animal is 213 kg. Milk yields are only one tenth in Africa and one quarter in South America and Asia of those in North America and Europe. These data suggest that major improvements in livestock productivity are possible. Research can provide technology to help achieve productivity increases but technology needs to be transferred to producers to ensure impact.

Livestock are a major component in agriculture in the developing countries and produce much more than food. Livestock and their products provide direct cash income, animals are a living bank for many farmers and are critical to agricultural intensification via provision of power and manure for fertilizer and fuel. They are closely linked to the social and cultural lives of millions of resource poor farmers for whom livestock ensures varying degrees of sustainable farming and economic stability. Exports earn foreign exchange to add to national reserves. Official statistics often underestimate the contribution of livestock and especially their multipurpose contributions to food and agricultural production. Livestock in developing countries often contribute more than 50 per cent of agricultural GDP and more than 20 per cent of total GDP.

Animal agriculture is often, and usually wrongly, seen as harmful to the environment. Global losses of tropical rainforest are of international concern and deforestation has been associated with increased production of greenhouse gases and global warming. Another global concern

is desertification. That livestock are a major factor in deforestation and desertification is a widespread belief in the developed world and affects donor contributions to research and development. Empirical evidence does not support the contention that livestock contribute to these problems.

Poverty is the main reason for farmers using practices that may result in natural resources depletion. Increased farm incomes from cash generating activities can lead to withdrawal from areas susceptible to degradation. Neither people nor policy makers in poor countries will feel much concern for the environment or biological diversity until basic needs are fulfilled and economic systems develop a capacity to respond to rapidly increasing demands for food. The immediate problem, therefore, is to get technology moving through national research systems and onto farmers' fields.

Background to the Roundtable

Concept

The Roundtable on Livestock Development Strategies for Low Income Food Deficit Countries was a joint undertaking between the Food and Agriculture Organization of the United Nations and the International Livestock Research Institute (ILRI). The initiative originated from informal discussions between the Animal Production and Health Division (AGA) of the Agricultural Department of FAO and ILCA (as it was then). FAO provided funds for ILRI to undertake the arrangements and also contracted an experienced writer and resource person to compile and edit the Proceedings. Preparatory work was undertaken by the ILRI Organizing Group who decided that it should directly follow the inaugural Board meeting of the new ILRI which combines the infrastructure and human and technical resources of the two previously independent centres, the International Livestock Centre for Africa and the International Laboratory for Research on Animal Diseases.

The presence of board members and experts with vast experience in livestock development from many parts of the world greatly increases the chances that the recommendations will be rapidly adopted by the international community. This is especially important for the time is opportune, with attention focused on the newly established ILRI, to put livestock back on the world stage where they rightfully belong. It is also important that the recommendations and rationale for development arising from the Roundtable reach the widest possible audience of policy and decision makers.

It is hoped that this Roundtable will mark the beginning of a period of greater cooperation between FAO and ILRI and with all the institutions and organizations represented. It should also result in a more rational and efficient use of scarce resources. An earlier Consultation hosted by ILRI in January 1995 to discuss A Global Agenda for Livestock Research complements this Roundtable. A further companion meeting organized jointly by FAO/WAAP will take place in May 1995 in Korea to discuss issues relating to the supply side of livestock products, especially to urban consumers.

Objectives and expected outputs

The primary objectives of the Roundtable were to:

- provide a forum for scientists and developers to exchange views and experiences; and
- raise the level of awareness of a broad and influential audience with regard to the potential and the constraints facing animal agriculture in low income countries.

The immediate objectives of the Roundtable were to:

- review the contribution and potential of livestock to increase sustainable food production, and contribute to income generation in low income countries with a forward perspective to 2020 ("The Global 2020 Vision for Livestock");
- identify major social, economic, technical and institutional constraints limiting livestock's contribution to achieving food security and economic development; and
- define appropriate strategies to alleviate these constraints and propose a framework for international action to enhance animal productivity.

The expected outputs of the Roundtable were:

- an analysis of past and present trends in livestock productivity and consumption of livestock products which would be used in part as an input to a "2020 Vision" paper to be further developed after the meeting;
- a defined set of objectives for the time frame specified and a related description of the constraints that must be overcome for the objectives to be achieved; and
- formulation of the set of measures ("a framework for action") or strategies needed for increasing livestock productivity in low income countries and securing better management of natural resources from the present to the end of the second decade of the 21st century.

Programme

The Roundtable was organized around four sessions. Session One started with a Keynote paper and two other background papers were presented to set the scene for the remainder of the programme. Session Two comprised two detailed papers that dealt in depth with major issues, constraints and opportunities for development. Session Three drew on the expertise of scientists and field workers to present a series of five papers covering the options for increasing livestock's contribution to human welfare from the world's major production systems and agroecological zones. These three sessions included discussion periods following the presentation of each paper and a fuller discussion of all papers together before the session closed. The last part of the meeting, Session Four, consisted firstly of detailed discussions by participants who were split into three Working Groups covering: sub-Saharan Africa and West Asia and North Africa; Asia; and Latin America and the Caribbean. Secondly, the conclusions and recommendations of these Working Groups were presented in a Plenary Session, again discussed and then formed the basis of the final presentation and recommendations.

Part One: Background papers

Keynote paper: The contribution of livestock to food security and sustainable development

Summary

This paper considers both direct and indirect contributions of livestock to food security and sustainable development in the developing countries. Major sections cover the meaning and scope of food security, livestock and food supply, livestock as a source of income, livestock as generators of employment and livestock as suppliers of draught power and inputs for agriculture. Livestock production in relation to resource management and environmental degradation and then trends and projections in food production are considered in two final

sections.

Conclusions and/or recommendations

The contribution of animals to agricultural and overall economic development has not been adequately evaluated. Statistics generally underestimate livestock contributions since many important non-food outputs which are difficult to quantify in monetary terms are excluded from calculations. The role of animals in development programmes is generally underrated in spite of the demand, especially in the developing countries, for animal products and services. Improved efficiency of animal agriculture with its various commodities and service products is critical to achieving sustainable agricultural development and food security, particularly in low income food deficit countries.

A prerequisite for sustainable animal agriculture is the development, testing and promotion of technology that uses local and affordable resources. Policies, infrastructure and support services must be established to enable technology to succeed and reach small scale farmers. Integrating livestock and crops increases the short term benefits to and the long term sustainability of agriculture.

The livestock sector is multipurpose and flexible and able to react to changes in national economies. Monogastric animals and ruminants are adapted to varying local conditions and use local resources to produce products and services. Increased productivity requires research to develop feeds and feeding systems, identify and use adapted genotypes, reduce mortality, improve production systems and inform appropriate policies. Pigs and poultry are likely to remain the main source of meat where rapid urbanization is occurring. Use should be made of transferable technologies to expand small scale production. Emphasis should be given to feeds that do not compete with human food.

Discussion points

This Keynote Paper incited discussion over a broad range of issues. Principal among these were the functions of livestock in mixed farming systems and their various roles in use of natural and other resources, the supply of and demand for livestock and livestock products, the development and transfer of technology to beneficiaries, policy issues.

Development support and livestock services

Summary

A developer's perspective of the current state of key issues in the establishment and functioning of effective livestock services for small holders in low income countries is presented. The paper covers issues and trends affecting all services. It uses examples from publicly funded development support for key services such as animal health, livestock extension, breeding, credit and marketing services.

Conclusions and/or recommendations

Livestock ownership is frequently equated with wealth but livestock development often benefits the poor. In Morocco and Egypt small farms have four to six times more animals per hectare than larger farms. Landless farmers in India and those with less than one hectare own more than 30 per cent of cattle and buffaloes and have four times more stock per hectare than larger farmers. Higher stocking rates may not result in optimal efficiency but they demonstrate the importance of livestock development for rural growth and poverty reduction. Effective and sustainable livestock services are a key issue in rural development policy and have attracted 30-50 per cent of international support for livestock development in the last 10 years.

Livestock services in developing countries have not been very effective, especially in reaching the poor. Two key factors - declining budgets and administrative efficiency, and changing clients, problems and issues - caused this lack of impact and led to a search for alternative systems.

The most important trends in the institutional organization of livestock services now in the mainstream of the current development dialogue are a better distribution between the public and private sector and greater decentralization and transfer of responsibility to direct beneficiaries. The public sector must maintain public good which it can (or must) do itself, can subcontract to the private sector under close supervision, or can transfer fully to the private sector and maintain only an overview function. Pure public good services include policy planning, quarantine, food inspection and quality control. Public service responsibilities which can be subcontracted to the private sector are goods with externalities, such as compulsory vaccinations, extension through the mass media and research that is not patentable. Pure private goods include clinical animal health care, animal breeding and credit.

Livestock development in low income countries needs to operate within the overall development objectives of reducing rural poverty, promoting rural growth and enhancing sustainable resource use. Future development support could therefore be expected to concentrate on three main areas: further fine-tuning of economic policies; strengthening services to small holders; and increased emphasis on environmental investments in the livestock sector. In the last case, subjects for emphasis might cover the whole spectrum from land degradation and management (especially in the arid zones), through programmes to reduce livestock methane emission and then to cleaning of the environment.

Discussion points

The discussion on this paper again covered a broad range of questions. The relative roles of the public and private sectors were considered very important. There was general consensus that clear distinctions must be made between the role of the state in public good areas and that of the private sector in private good areas. Privatization should not be pushed too fast where a private sector was not yet able to perform efficiently in the interests of producers and consumers. The role and timing of credit were also considered important.

Impact of human activities and livestock on the African environment: an attempt to partition the pressure

Summary

The impact of human endeavours on the environment in the struggle to eke out a living through crop and animal agriculture is examined in a holistic context. Analyses focus on all the sources of pressure that modify the vegetation cover of rural Africa, including the effects of fires and burning of biomass, fuel wood extraction and deforestation and land clearing.

Conclusions and/or recommendations

Direct and indirect impacts of livestock production on the natural resources can only be assessed as an integral part of the overall pressures that human activities exert on the environment. Work on the dynamics of Sahel ranges shows that livestock are not a major factor in degradation. Even under extreme grazing during droughts less palatable and lower productivity plants supplant more palatable and more productive species only in the short run. A recent review concludes that the effects of grazing and drought are confused and that there is no solid evidence of irreversible effects on vegetation from livestock except around water points and permanent human settlements.

Woody cover in African drylands has decreased at a rapid rate, especially in the arid and in

the drier parts of the semiarid zones. Soil degradation is less serious on crop than on rangelands with 75 per cent of the drylands being unaffected. Soil erosion, shifting sand and surface crust formation impeding infiltration and promoting run-off are among the major causes of soil degradation. It is probable that depletion of soil organic matter and nutrients is the most common cause of degradation.

Fire is responsible for 42 per cent of gross atmospheric emissions of CO₂ to which Africa contributes 43 per cent, this exceeding the combined emissions of South America and Asia (39 per cent). Savanna fires consume more than 80 per cent of all burnt biomass. The impact of fuel wood use by rural populations and urban centres on wood resources and vegetation structure is a major pressure on the environment. In rural Africa, 80-90 per cent of the energy demand is derived directly from woody vegetation and wood-derived charcoal is an important source for food preparation and heating in the urban sector. Deforestation and land clearing for crops are other major sources of degradation.

Partitioning of biomass removal reveals the relative importance of the pressures exerted by human activities. By assessing support capacities for crops, livestock and fuel wood an aggregate index could thus emerge that would measure overall impact on the environment. Depending on ecosystem resilience -emanating from climate, landscape and soil and vegetation cover characteristics - risks of degrading processes and their resulting impact could then be identified. Causes of degradation such as wind and water erosion and nutrient depletion in soils due to crop and biomass removal could be given importance rankings and then aggregated.

Impact assessment could be incorporated into procedures developed by FAO to estimate the human support capacity from assessment of potential yields and outputs of crops. Conversion of yields of appropriate crop mixes into calories and protein enables computation of potential population densities that the food output can support. Comparison with present and future anticipated densities allows identification of critical areas where food output is or will be insufficient to meet minimum human needs. Livestock and fuel wood productivity models have recently been added by FAO to the estimation of potential productivity of land resources. These models, designed to operate on a digitalized land resource data base, include provisions for quantifying soil erosion hazards and resulting estimates of "tolerable" soil losses. Since the models are interphased, land productivity can be optimized for any set of development constraints and demand. A contextual framework thus exists that incorporates the essential building blocks for assessing whether current land use is sustainable and this framework could accommodate location specific data sets to estimate environmental impact.

Discussion points

There was general consensus during discussion that the role of livestock in resource degradation was still largely misunderstood in the broader world but that this ignorance resulted in negative effects being exaggerated. Methodologies need to be developed to study environmental issues. Proper presentation of results is also needed to avoid adverse criticism.

Part Two: Issues/constraints and opportunities for livestock development

Macroeconomic, international trade and sectoral policies in livestock development

Summary

Following a general introduction Section 1 reviews regional trends in production, consumption and trade and highlights some related policy issues. Section 2 then considers in conceptual terms the importance of macroeconomic, trade and other economic policies to provide a basis

for the remainder of the paper. Section 3 examines agricultural and livestock development in major developing regions in relation to macroeconomic and trade policies whereas Section 4 looks at livestock sector policies. Recent West African experiences in livestock production and trade against a background of changes in international and regional economic policies are the focus of Section 5. The concluding Section 6 focuses on appropriate economic policies for livestock development in low income countries.

Conclusions and/or recommendations

Macroeconomic, trade and sectoral policies are among those affecting the livestock sector in addition to public infrastructure, animal health services and investment in processing and marketing facilities. Because many services are public goods and essential to the success of other economic reforms governments needs to promote or provide them.

Policy should promote optimal use of domestic resources for both local consumption and export. The specific economic, social and natural resource characteristics of each country and the varying potential for livestock sector growth mean that policies must differ from country to country. Each country's production potential, consumption profile and market opportunities will determine livestock's role and the areas in which governments might seek to promote greater market efficiency.

The institutional capacity for micro and macroeconomic analysis of livestock issues is limited in most low income developing countries. For low income exporting countries, greater familiarity with international market developments is especially important, as is the development of more accurate and comprehensive data bases for policy analysis.

International market instability and distorted world prices create major policy dilemmas for developing countries that can produce livestock at relatively low cost. These dilemmas include whether world prices that are primarily the result of distortionary policies in developed countries should be used, whether to import lower cost livestock products because they benefit consumers despite the negative impact on producers and long term growth, and whether to protect domestic producers to encourage development of their own livestock sectors and thereby forego the benefits of low import prices.

Economic theory suggests international prices as the best measure of opportunity cost and determinant of domestic prices. The argument for using world prices depends only on the fact that they are fixed from the point of view of the country concerned. Each country needs, however, to make a critical appraisal of its own situation to arrive at a desirable solution. Careful assessment should be made of the possible extent to which inappropriate domestic policies are also important factors in the unsatisfactory performance and contribution to overall economic growth and poverty alleviation of the agricultural sector in general and the livestock subsector in particular.

The processed food sector offers opportunities for growth especially in Latin American and Asian countries already involved in exports. In the medium term low income countries in the Sahel and other developing regions might be able to increase production of dairy and other processed products to meet expanding regional and local demands. Beyond regional markets there are formidable barriers. To overcome these, developing countries need to engage in frequent negotiations with the industrial countries for better market access and seek agreement to be consulted in the setting of food import standards. Developing countries also need to encourage foreign investment in domestic industries in order to get support from the multinational firms that dominate world food markets.

In all regions, but especially in sub-Saharan Africa, governments must ensure the availability of the infrastructure and support services that producers need in order to be able to respond

effectively to price incentives. Governments also need to help develop private sector capacity where state marketing boards are being dismantled and the private sector appears unable to respond to the new marketing environment.

Discussion summary

There was animated discussion on this paper and more detailed explanations were called for in some aspects. It was emphasized that the analysis in the paper does not support active government intervention to limit trade in order to further existing or new development policies. It was also pointed out that livestock sectors have suffered from policy interventions due to the anti-agriculture bias displayed by the economywide and sector policies adopted in most developing countries.

Research and technology transfer for livestock development

Summary

A framework for international action to support livestock development is presented and discussed. The goal is to help achieve increased and sustainable food production and generate revenue for improved food security in low income countries. This goal conforms to the global mandate of ILRI which, although its main function is research, cannot ignore the linking of research to technology transfer if it is to make an impact. Issues related to the role of livestock research in strategies making up the action framework and especially effective linkage with technology transfer are discussed. Africa is the focus, because, although it is not unique in facing the problems of low income countries, it provides the greatest challenge to the global agricultural development community.

Conclusions and/or recommendations

NARS need not only trained personnel but also adequate funds to cover fixed and operating costs if they are to function effectively. Government funding for livestock research has rarely been sufficient and has often been used ineffectively. Average expenditure on agricultural research for less developed countries in 1981-1985 was in the range 0.54-0.94 per cent of agricultural GDP, this being about a quarter of the percentage investment in developed countries. National resources are used mainly for staff salaries, which often account for 90 per cent of the total budget, and infrastructure. Donor funding is thus most often used for the marginal costs of experiments. Many NARS are still considered to be performing badly in spite of donor aid.

A human capacity/institution building model must replace long term technical assistance in order to develop national capacity. Building effective systems capable of doing adaptive as well as applied research requires continued investment in higher education in the agricultural sciences. IARCs can play an important role in capacity building through training and collaborative research. Short courses should be supported by research training to collaborators in the context of projects undertaken in CGIAR-sponsored cross-centre and ecoregional initiatives. CGIAR scientists can also act as technical resource persons in applied and adaptive research projects. Increased efficiency will result from regional groupings of NARS or using established networks to carry out this research.

The action framework needs to include research and technology transfer policies. It also needs measures to promote increases in agricultural research investment within the framework of the new human capacity and institution building model. The effects of macro and sectoral policies affecting research impact also need to be considered as do international concerns about the consequences of livestock development on the environment, human health, equity and other critical issues.

An effective mix of research types and the strengths of all partners in global research and development need to be included in strategies that promote livestock development goals. Models such as CGIAR ecoregional projects, the CGIAR systemwide livestock initiative and the ILRI conceptual framework for dairy research provide useful examples. Organizational models that ensure transfer of new technologies are also needed and must include international organizations and NGOs. FAO/IARC cooperation is a useful model for effectively linking research and technology transfer.

To accomplish the framework's objectives explicit measures will be required to harness resources and ensure impact. Such activities could include:

- an ILRI/FAO/IFPRI policy unit charged with carrying out impact and policy analysis, educating the public, and garnering advocacy and support for livestock development; and
- a livestock policy network such as that seen as part of the ILRI/IFPRI project on the determinants of dairy demand, which could help train NARS scientists in policy research and analysis and could be tied to the previously described policy unit.

Using these two structures, a "2020 Vision for Livestock Development" could be mounted to promote the message of the positive effects of livestock development for the public, interest groups and donors in the developed countries. These tangible measures would ensure that the framework for action is translated into reality and result in livestock development that will have a strong impact on human well being in low income countries.

Discussion points

There was some concern that direct participation by the beneficiaries – the small farmers – was not accorded sufficient attention. This argument was countered by the fact that the social dimension is included to the extent that the recommendations will positively affect farmer welfare. There was avid discussion on the role of research and how it should be funded. Consensus was difficult to reach on the latter, mainly because of efficiency issues with the public impression being that staff numbers and therefore expenditure had increased relative to operations in recent years. It was agreed that this should be viewed in the light of initial low staff numbers and salaries. The role and methods of technology transfer were discussed especially in relation to the framework of the proposed policy unit.

Part Three: Options for increasing livestock's contribution from the major production systems

Redesigning for risk: tracking and buffering environmental variability in Africa's rangelands

Summary

Changes in the way rangeland development projects have been conceived and operated and better understanding of the priorities and strategies of traditional pastoral systems are the subject of this paper. Using a traditional conceptual framework approach, changes in overall objectives, project purpose, results and activities in relation to intervention logic, achievement indicators, sources of verification and assumptions are reviewed and compared for "ranching model" projects of the 1960s and 1970s and "tracking and buffering" projects of recent years.

Conclusions and/or recommendations

In the 1960s and 1970s the blueprint for African range and livestock development projects was

the ranching model. By the early 1980s poor performance had subverted confidence and a decade of experiments involving large and small donors ensued. This was accompanied by extensive field research (including pastoral systems studies conducted by ILCA) and theoretical retooling (notably in scientific ecology). Much of this was innovative and practical but it did not provide a framework for assembling new research ideas and intervention techniques into an adequate policy for rangeland development. Recent advances in scientific ecology and pastoral studies have also failed to "solve" the overstocking problem and have not suggested more effective ways of removing surplus animals. They have, however, encouraged a reframing of the problem.

Typical projects of the 1980s sought to provide services, improve welfare and pastoral incomes, or develop pastoral community organizations. They had little success in accounting for how these activities contributed to sustainable resource management and its links with economic development.

Changes in the 1990s are underlined by abandoning of the earlier goal of "rangeland conservation" in favour of "sustainable rangeland production". Applied research on pastoral economies shows that priorities hinge on the volume and kind of produce and, contrary to the assumptions of the ranching projects (which were that sales equalled income), that traditionally managed livestock often provide their owners with cash and in kind benefits in excess of those derived from additional animal sales.

The dominant variables driving ecological changes on communal rangelands are physical factors, such as rainfall, outside management control. In these event dominated systems it is unrealistic for managers to try to forestall environmental change by tinkering with a single dependent biological variable such as livestock numbers. Managers who cannot control their environment must quickly adapt to it if they are to minimize the consequences of unpredictable rainfall. This opportunistic approach demands temporary but sudden and very substantial adjustments in livestock feed demand in response to abrupt changes in feed supply. Flexible exploitation strategies must be profitable as well as environmentally beneficial if producers are to adopt them. In other words, environmental concerns dominate project objectives but economic ones define project purpose. These dual intentions require both biological and economic indices of success – tracking and buffering of environmental fluctuations. Tracking refers to the biological phenomenon of prompt adjustment of livestock feed needs to fluctuating levels of primary production. Buffering refers to the economic phenomenon of shielding of pastoral incomes from the worst effects of violent climatological and biological changes.

Field research on problems of opportunistic management would undoubtedly produce more precise recommendations or increase confidence in those already proposed. Some activities such as paraveterinary programmes, water harvesting and famine early warning systems are ready for large scale use. Other potential project components such as famine relief, land tenure, livestock marketing and forage production still need research and field experimentation but are likely over the long term to improve the tracking and buffering of environmental variability in Africa's rangelands.

Discussion points

The role of research was the main focus of discussion. There was general agreement on the need for policy research and that institutions such as ILRI have a comparative advantage in undertaking surveys among systems. The concepts of "tracking" and "buffering" raised both comment and required clarification. Land reform and tenure were discussed with a consensus that widespread agrarian reform for communal areas is neither desirable nor feasible but that there is a need to explore other forms of tenure that allow for greater control of "key" resources such as dry season grazing.

Mixed farming systems in sub-Saharan Africa

Summary

The important position and role of mixed farming systems in land use intensification in sub-Saharan Africa is reviewed. This is done by examining the current situation that is followed with a justification for mixed farming. Further sections follow on changing patterns of land use, including the effects of tsetse flies and trypanosomiasis, and on constraints to further crop-livestock integration. Research needs are considered in a final section with particular emphasis on biophysical factors (feed development, nutrient management, dual purpose livestock, animal health, genetic improvement and natural resource management) and policy analysis.

Conclusions and/or recommendations

Development objectives for sub-Saharan Africa are moving towards resource conservation and natural resource management while striving for greater agricultural production. Economic growth must increase by 4-5 per cent annually if food security is to be achieved and a modest standard of living provided for the 1.3 billion people expected in the region by 2025. Rapid urban population growth (55 per cent of Africans will live in urban areas in 2025) and higher incomes will create a need for better quality food, particularly of animal origin, from a rural population that is expected to feed 592 million by 2025 compared to 350 million in 1990. This is an enormous challenge in a region that experienced a negative per caput GDP during the 1980s.

Strategies designed to raise the productivity of specific mixed crop-livestock systems must consider the stage of development of the target area in relation to intensification and the nature of crop-livestock interactions, the availability and cost of inputs, and whether or not policies favour mixed farming. No one set of actions is applicable to all situations. Mixed farming is an option for increasing agricultural productivity while ensuring environmental safety in the semiarid, subhumid and highland zones.

Mixed farming is developing naturally in many areas of sub-Saharan Africa. At present economic levels livestock seem a viable alternative to manual labour and they help to replenish soil fertility and provide cash income for household needs. Production increases need to be rapid and sustainable and guarantee the well being of all. In order for this to be achieved political will and national commitment need to enact the required policy changes to intensify agriculture.

Discussion points

Discussion focused on the likelihood and impact of intensification including competition for land and labour. New technologies were considered important in the intensification process although the poor past performance of "technology transfer" and the lack of research relevance were noted. There was no consensus that integration and intensification is the only way forward. It was pointed out that many arable farmers do not own animals and those who have do not necessarily have the incentive to integrate or commercialize. The need for characterizing integrated farming systems by various economic, environmental and social indicators was discussed.

Livestock, feeds and mixed farming systems in West Asia and North Africa

Summary

This paper looks forward to 2020 in the West Asia and North Africa (WANA) region, extending from Morocco in the west to Pakistan and Afghanistan in the east and from Turkey in the north

to Ethiopia and Yemen in the south. Prospects for crop and crop residue production, range capacity and livestock and feed deficits are reviewed. Macrobalances of food, feeds and livestock are projected in relation to human population trends. Case studies of flock diet calendars for small ruminants and whole farm economic views of mixed crop-livestock systems are presented. The ways in which microlevel balances help in understanding how livestock management options affect cropping decisions while country macrobalances determine the economic contexts of livestock production are demonstrated.

Conclusions and/or recommendations

The region has large areas with winter rainfall and hot dry summers. Population increase has been rapid in the past and many countries will have accelerated growth at least up to 2020. The social as well as the physical ecology of the region must be respected in deciding on policy and production.

Policy issues remain a problem. In many countries grain is heavily subsidized as feed for animals. Rangeland tenure and farm level decision making need attention, the informal seed sector need supports and more support is needed for improved on-farm livestock management and nutrition. Management issues should have more attention paid them to bring them into better balance in relation to the current emphasis on veterinary and animal breeding investments.

Food and feed demand have grown faster than domestic production in most countries and will continue to do so. The resource base for traditional animal production, mainly native rangelands and crop residues, is under increasing pressure and large future feed deficits are projected. Differences in income, food and feed supplies are so great among WANA countries that indiscriminate aggregations of their prospects can result in serious misconceptions. Smaller groupings are proposed to distinguish clusters with contrasting prospects in an attempt to prevent these misconceptions.

Microstudies of mixed systems show the adaptability of animal diets by means of diet calendars and of crop-livestock mixes on individual farms but the microview of improved mixed systems offers only partial relief from the gloomy macrovision of rising feed and livestock deficits in the region's future.

Discussion points

There was discussion on the sustainability of many current practices, particularly the use of subsidized feed grain and its consequences. The future for many countries is bleak, especially those lacking a potential manufacturing base or mineral wealth. Self sufficiency in grain or animal products is unlikely although rotations incorporating legumes might increase overall production and have the additional effect of increasing the amount of animal feed. Considerable interest was expressed in the survey methodology used by ICARDA and its potential for use by NARS.

Constraints and opportunities for livestock development in mixed farming systems in Latin America and the Caribbean

Summary

Opportunities for development of the animal component of mixed farming systems in the tropical countries of the region are examined. The emphasis is on cattle because they are the most widespread species and contribute nearly half the meat and almost all of the milk produced in the LAC countries.

Conclusions and/or recommendations

Mixed systems that include crops and livestock are widespread at all altitudes in Latin America and the Caribbean (LAC) on small and medium sized farms. On larger farms, as in the South American savannas, integration is becoming common despite traditional separation of crops and livestock.

Major social, economic and environmental changes took place in the region in the last 20 years including stagnation or a fall in GDP, hyperinflation, acute fiscal deficits and large foreign debts. Population growth was more than two per cent per year. Macroeconomic adjustments to reduce market distortions and public deficits have been harsh in the short term. They have included removal of subsidies and caused lower production of staple foods, widespread unemployment and reduced social services. Public spending on agricultural research and support has decreased. Civil disturbance, organized violence and crime symbolize the period. Recent improvements in some countries have been offset by deterioration in others and international war returned to the region in 1995.

Milk and beef are important in the Latin American diet. Overall average consumption of milk and meat per caput remained fairly static between 1976-1983 and 1984-1991 but more countries recorded decreases than increases in both products, especially in Central America and the Caribbean.

Total milk production has increased by about two per cent per year since 1976 but has generally failed to keep up with population growth. Tropical LAC produced 88 per cent of its milk requirements during 1984-1991. A deficit of nine million tonnes is predicted for the year 2000. Beef production has increased more rapidly than milk. Most expansion, however has been from increases in inventory as yields per head have remained fairly stable. The region has been a net exporter of beef over the last two decades but a shortfall of 356,000 tonnes is predicted by 2000.

LAC has a privileged situation compared to other parts of the tropical world but has major problems of poverty and violence, declining standards of living and environmental degradation. Cattle have an important role in improving this situation and there is much current technology to do this. Yet progress has been slow and opportunities lost. A holistic, integrated concept of livestock production is the most important factor for harnessing resources and catalysing change. Once this is in place, policies conducive to the sustainable development of systems including livestock will be set more widely and appropriate research and training to serve the region's future needs can be undertaken.

Discussion points

Discussion centred on what many participants obviously considered controversial matters introduced by the speaker. There was concern in particular about remarks that extension workers were not needed as farmers acted as their own extension agents as well as about the need to avoid continuing with farm surveys over long periods of time without achieving tangible results. The amount of information available and its accessibility and transfer were also major points of discussion.

Mixed farming and intensification of animal production systems in Asia

Summary

Mixed farming systems are discussed with reference to general characteristics, economic importance of animals, genesis, types and relevance of crop-animal systems, and priorities for research and development. Mixed systems are found in rainfed areas in the temperate and highland zones, humid and subhumid tropics and arid and semiarid subtropics and under irrigation in the humid and sub humid tropics and arid and semiarid tropics and subtropics.

The relevance of integrated crop-animal systems is highlighted with reference to advantages, synergism and complementarity, economic benefits and sustainability. Illustrative cases of two broad types of mixed farming systems combining animals and annual cropping and systems combining animals with perennial cropping are presented.

Conclusions and/or recommendations

The economic importance of livestock in Asia is reflected in their contribution of 10 per cent of the total value of commodities, this figure being the highest of all the developing regions. The largest contribution within agroecological zones of 44.9 per cent is from the warm humid/subhumid tropics and subtropics, the arid and semiarid tropics with summer rainfall being next with 37.6 per cent.

Increased investment in research in the rainfed warm humid/subhumid and arid/semiarid tropics is necessary together with strong multidisciplinary efforts to address the more complex problems associated with natural resource use and management in mixed systems. The potential benefits are directly associated with a more concerted role for animals, increased productivity from these zones and demonstration of environmentally sustainable mixed farming systems.

Opportunities for research and development to overcome existing constraints are enormous and the contribution of animals can be greatly increased. Reorientation of programme focus and direction is necessary to achieve this, using multidisciplinary strengths in target agroecological zones. Holistic research on mixed systems has been weak and most past research has been on cropping systems. Inclusion of animals in systems research began only 10 years ago in some countries. Some progress has been made in the development of methodologies to understand the interactions between subsystems but much research has been sporadic and has not been tested on a large scale. Research needs in support of crop-livestock-tree systems include baseline studies to quantify energy flows, simulation models to identify possible coefficient changes, field testing of interventions and new technology, and "test marketing" of proposed developments on typical subpopulations within the region.

Better use of animal genetic resources is necessary to maximize productivity. Dairy production, for example, has received major attention in almost all countries and has had varying degrees of success but is hampered by yield-reducing environmental stresses, inadequate feed production and poor nutritional management, high capital costs, limited market size, low cost of competing imports and product perishability. Investment in these programmes has been enormous but returns are essentially short term and long term viability is very doubtful. An associated inability to sustain breeding and maintenance of crossbred animals is a further problem. Such massive use of resources has diverted attention from more balanced development and use of other species to increase protein production. Notable in this regard are beef cattle, swamp buffalo, goats, sheep and ducks. Many potentially important breeds have never been adequately used and many are destined for extinction.

Feed is the principal constraint among the non-genetic factors affecting productivity. Ruminant feed resources are greatly underused. Better feed use is hampered by low animal numbers, inadequate intensification of the production system and poor technology delivery and use. The approach should be towards a balanced feed supply, with balanced energy/protein ratios and correction of critical deficiencies with low cost supplements. In areas where livestock are the basis of the economy and the production system is largely pastoral increased fodder production is necessary as are corrections to problems of mineral deficiencies. Research into these and other constraints provides a major challenge for rangeland ecology and national livestock production.

Inadequate, inappropriate and inefficient technology use is a major limitation to increased

animal output. Technology application at farm level is especially weak and is related to poorly formulated development programmes that often preclude strong interdisciplinary team effort and concerted on-farm use. Large scale on-farm testing is needed, involving a major shift to participatory development.

Successful project implementation needs strong policy support. A reorientation of animal production programmes is required to deal with more complex multisectoral and multidisciplinary projects that address natural resource use and management and that provide for environmentally sustainable development. Some factors to be considered include watershed management, nutrient recycling, biodiversity, changing socio-economic conditions and attitudes, and consumer preferences.

Discussion points

The complexity of Asian systems was a major focus of discussion. Non-ruminants are very important and may need more research. It was agreed that conventional and non-conventional systems are evolving rapidly in response to population growth and urbanization. More information on the extent of the positive and negative (including waste generation) changes taking place would be useful.

Part Four: Working groups and Final Plenary Session

Introduction

Working groups were assigned three tasks:

- Task One was to review changes that have taken place in the supply and demand for livestock products over the last 30 years. The analysis was to include directions in input use and resource management and degradation and identification of the factors underlying these changes, such as macroeconomic policies, institutional elements, trade, urbanization and population growth. The output was expected to contribute to a report on past and present directions in livestock productivity and consumption of livestock products as part of a forward looking 2020 vision paper to be produced later.
- Task Two was to identify the key goals and opportunities for livestock development over the next 25 years by major agroecological zones and the major social, economic, environmental, technical, policy and institutional constraints to achieving these goals. The expected output was a clear statement of defined goals and opportunities for livestock development that could realistically be achieved by 2020 and a related description of the set of concerns and constraints that must be overcome for the goals to be achieved.
- Task Three was to identify appropriate strategies for the goals identified in Task Two, including actions on- and off-farm at the national level, and at regional and international levels, in order to improve livestock production and the research and development implications of these actions. The temporal, spatial and social implications of these actions were to be indicated if possible. The expected output was a clear formulation of the measures required for achieving better management of the natural resource base to 2020.

Group One - Sub-Saharan Africa and West Asia and North Africa

Task One: Sub-Saharan Africa

General trends have been away from extensive and mobile range systems towards more

intensive and sedentary small holder agropastoral and mixed farming systems. Some data are available on **research and extension** funding, human resource situations and levels of **training** but there is no political lobby or domestic constituency for long term agricultural research. Structural adjustment has improved the image and acceptance of policy research but associated budget cuts have had a negative effect. Link between research and extension are generally poor. Vocational training and farmer education require strengthening but a training needs assessment is required. With regard to **resource management and degradation**, it is not possible to identify trends until a workable definition of degradation is agreed. If soil nutrient depletion is a good criterion degradation on crop lands may be serious but it will be much less so on grazing lands. Awareness of natural resource management problems is improving. NGO interest is high but their effectiveness is unpredictable because they lack appropriate technical knowledge. In the field of **policy**, devaluation has a negative effect on high input, intensive, import dependent systems but favours those based on domestic natural resources. Anti-agricultural trade, marketing and exchange rate policies are changing and have already had an effect on trade. Badly conceived domestic sectoral and trade policies can offset the benefits of devaluation. Correlations between **tenure** reform and changes in agricultural output are weak and other constraints to better performance are more important than deficiencies in land laws.

Task One: West Asia and North Africa

Livestock product supply is well below demand and the **general trend** is downwards. Most countries are net importers of livestock products. **Socio-economic and development indicators** show the share of GDP derived from agriculture to be good. Some countries, through **policy instruments**, are committed or attempting to implement structural adjustment programmes but others are resisting them. Rangeland **tenure** policies vary although there has been a general trend towards privatization. Most WANA countries have had politically motivated land reforms that have been variously effective. Production quotas remain for several critical crops but movement and sales controls are now being removed. The primary effect of irrigation is through fodder crop production and the use of crop residues. **Credit** availability has promoted livestock production. **Extension** services are weak in technology transfer and often act as state agricultural police but there are some signs of improvement. Expenditure on agricultural **research** is low in relation to GDP. Road and railway **infrastructure** is generally better in WANA than in sub-Saharan Africa. There are regional organizations and some potential for regional **market** integration but there is generally not much current activity.

Task Two: Sub-Saharan Africa

Development prospects over the next 25 years seem bleak without fundamental policy reform and technical innovation. The importance of small ruminants is likely to increase with increasing population pressure and declining farm size in the semiarid zone. There is potential for increased dairy production but appropriate policies are required. Fattening operations can be expected to develop where feed is available. There are prospects for expansion and intensification in the subhumid zone where cattle will take precedence over small ruminants but the output mix will depend on prices. Larger crop areas will have a negative impact on migratory livestock producers who will tend to settle. Tsetse flies will decline in importance as cultivation spreads and *Bos indicus* cattle will expand at the expense of trypanotolerant *Bos taurus* types. In the humid zone it is likely that crop-livestock integration will be limited to economic links but poultry and pig production will probably expand. The disease challenge is high but there is good potential if the considerable health and management problems can be overcome. The main consuming areas in the humid zone give it a comparative advantage for final fattening but there will be a need to control potential environmental pollution. There are possible resource degradation problems in parts of East Africa. Soils are better than in West

Africa so nutrient depletion is less of a risk but slope and wind erosion may be problems. The bimodal rainfall pattern allows pastoralism to penetrate deep into relatively high rainfall areas. Subhumid lowlands in parts of East and Southern Africa have low population density and high potential if tsetse problems can be overcome. Root crops are expanding in these areas which may limit integration possibilities. There is potential for intensive livestock production for small scale pigs and poultry in Southern Africa in general. The highland areas can be considered as a series of subzones with different sets of advantages and problems. In the "roots and beans" highlands the demand for livestock products is limited by low purchasing power of consumers and continued civil strife is a problem. In the "dairy" highlands land is the scarcest production factor but further specialization in the vicinity of urban areas can be expected. Temperature is the limiting factor at high altitudes in the "grain" highlands where extensive sheep grazing predominates and prospects for more efficient production through fattening are good. Dairy production is likely to replace the oxen/cereal system at middle altitudes as farm sizes become smaller.

The **major causes of concern** are security at the local level, especially between pastoralists and farmers over crop damage and competition for scarce resources, and civil war on a wider scale. Human health problems and weaknesses in the marketing system are additional problems. Concerns about animal welfare and the environment will assume increasing importance.

Task Two: West Asia and North Africa

A major **general goal** is to exploit the comparative advantage presented to livestock by crop residues and native pastures and the integration of forage crops, feed grains and agroindustrial by-products in livestock diets. Nutritional management of small ruminants should be improved to avoid feed wastage and to make better economic use of animal genetic potential. Expansion of meat, dairy and poultry production based on domestic and imported feed grains and agro-industrial by-products should take place where there is a comparative advantage in so doing. An **institutional framework** for the most appropriate management of rangelands is missing. **Development prospects over the next 25 years** are that West Asia and North Africa will continue to be the biggest importer of livestock and livestock products in the world and will be a major potential market for sub-Saharan Africa. There are prospects for intensifying existing mixed farming systems through the use of external feed resources and forage crops. Intensive horticulture may compete with intensive livestock production for capital and scarce natural resources. There is considerable potential for increased milk production if suitable policies are put in place. More intensive production will increase the absolute value of livestock output but livestock's contribution to GDP may show some decline. An **area of concern** is that there is no unused land and no possibility of horizontal expansion so increases in output must come through intensification and irrigation.

Task Three: Sub-Saharan Africa

In the low potential areas comprising the arid and part of the bimodal rainfall semiarid zones there is some need for development and employment of both existing and new **technology** but **policy** and **institutional** factors are of greater importance. All of the **technology, policy** and **institutional** spheres are in need of very strong support in the high potential areas of the semiarid and subhumid zones and that part of the highlands with good development opportunities where returns to investment should be very high. Highland areas with high population densities are considered to be of reasonably high potential deserving of strong support and returns to all of the **technology, policy** and **institutional** spheres should be reasonably high. There is little need for **technology** or **institutional** support for agribusiness but the **policy** area needs clarification.

Task Three: West Asia and North Africa

In the arid zones (< 200 mm) where range and pastoral mountain systems are dominant **technology** should focus on known techniques to arrest degradation and possibly to increase productivity. In the **policy** area there is need for clarification of property rights and establishment of appropriate communal or private management. There is typically weak **institutional** capacity at the national level and political and legal issues are not well understood. There is potential for social conflict in many countries. Partnerships between IARCs and NARS on strategic issues related to interactions between technology and policy are essential to the development of sustainable management.

In the cereal-legume mixed farming semiarid zones with 200-450 mm annual precipitation the **technology** focus on introduction of legumes, especially forage legumes, has had limited success. Adoption rates for seed and fertilizer technology for barley production have been low. Sheep are the key enterprise on many farms. The main focus should be on economic integration for optimal nutritional management of small ruminants. **Policy** must focus on integration of cereals and legumes with small ruminants. Strategic research is needed on price-subsidy relations, structural adjustment, comparative advantage and factor availability. The **institutional** capacity of NARS must be strengthened and governments must increase funding to research. The effort devoted to management and nutrition of small ruminants should be increased to bring it in better balance with existing efforts on animal breeding and veterinary services. IARCs must work together on policy, trade, price and factor issues to balance long term strategies against social disfunctions due to sudden policy changes.

The subhumid zones where precipitation is in the range 450-1200 mm have considerable diversity with emphasis on winter wheat, horticulture and industrial crops and intensive dairy, feedlot and poultry enterprises. Long term **technology** issues relate partly to the management, scarcity and competition for water and potential pollution of the environment by agroindustries and feedlots. Current technology and knowledge is adequate for short term management of resources through NARS. There appears to be no major need for IARC involvement. There is a need for greater **policy** emphasis on strategic issues affecting resource use, inputs, import and export issues and markets for horticultural products. The scope for integrating crops and livestock within and across ecozones and within existing land use patterns must be further defined. **Institutional** needs relate to integration of livestock with crops and rangeland, inadequate links between research and extension for technology transfer and feedback to policy, development of effective mechanisms for people participation in improved range production, encouragement of appropriate privatization of services, consideration of who should do strategic research on major animal diseases, seed deficits, and macroeconomic distortion.

Cold winters and transhumant livestock compound **technology** problems in the highland zones. Integration with the rest of the region to assist trade and poor infrastructure in remote areas are **policy** domain concerns. Low literacy and poor technology uptake are among the **institutional** problems.

Group Two - Asia

Tasks One and Two

The three major agroecological zones are the **humid and subhumid, arid and semiarid and highland** zones. Analysis of trends over recent years and expectations and identification of opportunities indicated that investment in livestock research and development has been falling in Southeast Asia but the current rate of decline is expected to slow down. Human populations will rise rapidly but this will be accompanied by an increase in average incomes. The rapid increase in crop area should not continue and a change to oil palm, rubber and citrus fruit tree crops may reduce the total crop area early in the 21st century. Increases in livestock numbers will mainly be in pigs and poultry.

Task Three

The initial emphasis was on opportunities, constraints affecting them and supporting research and development strategies in order to define broad priority research spheres. Six major research areas were identified within which specific issues were further indicated. These, ranked in order of importance, are feeds, systems, genetics, policy, socio-economics, and health policy. Within each research area the magnitude of a particular constraint was further identified.

In the **humid and subhumid** zones feed use requires more research than conservation or production. Capacity is lacking in systems research and has the highest priority with methodology being next, followed by environment, watershed management and dynamics. There is only low priority for research on plant and animal genetic resources. Domestic policy requires average resource inputs as does scenario development in the socio-economics area. Community development in the socio-economics area demands few resources in all three agroecological zones as does health policy.

In the **arid and semiarid** zones most emphasis is needed on feed production and animal movement in systems research. Average resources should be directed to feed utilization, systems dynamics and methodology, animal genetic resources and socio-economic scenarios. Relatively little support is needed for systems environments and research capacity, plant genetic resources and domestic policy.

In the **highlands** high priority is needed for feed production and animal movement in the systems area. Conservation and use of feeds is of medium priority as are systems dynamics, watershed management and methodology. Domestic policy and socio-economic scenarios should also receive average priority. Least use of resources is demanded by environmental research and research capacity in the systems area and by animal and plant genetic resources.

Development must be a partner in research. If both research and development efforts focus on defined problems the outcomes for low income farmers and livestock herders are likely to be significant increases in productivity. The development focus should be on **lowland rainfed** systems. The core themes could be community development to encourage local groups to improve the productivity of the resources they manage, applied research and technology transfer with a view to substantially improving linkages between research and extension, increasing the efficiency of extension and adapting strategic research findings to local conditions, and price policy so that the probability of adoption of general recommendations arising from pure policy research is high. Links between research and extension could be further strengthened by setting firm time specific targets. Field rather than station research might be an important element in the pursuit of such targets.

The efficiency of many research and extension programmes is low. Attention should thus be given to the development of indicators of effectiveness so that there will be faster transfer of potential benefits at less cost. A parallel problem is lack of awareness of emerging research technologies and methodologies among scientists working on core problems, particularly in the suggested focus on the development of systems thinking and integrated systems. A third aspect is the need for a forum to bring together research and development specialists to develop, for Asia or by theme, draft proposals, act as a coordinating body, and evaluate and/or supervise projects where this is appropriate. In all these developments maximum use should be made of existing bodies and structures.

Group Three - Latin America and the Caribbean

Task One

Indicators selected for this task relate to demography, macro and trade policies, consumption, imports, exports, inflation, land availability and use, income, impact of attitude to adoption of new technology, trends in production systems, product yields and offtake rates, input sales for livestock, importance of livestock products in diets and elasticities of demand, structural adjustment programmes leading to opening of markets, and regional and international trade agreements. The human population is about 450 million of whom more than 50 per cent live in urban areas. Cultivated land is equivalent to 0.43 ha/caput and grazing land to 1.27 ha/caput, both these being considerably higher than the average for all developing regions. Crop and livestock output per caput is also relatively high, the latter being more than two and a half times that of low income countries as a whole.

Milk production increased by 23 per cent from 1985 to 1990 but was mostly from more animals and not from higher production per animal. Beef production is 13.9 per cent of world output. As for milk, production increases are mainly from horizontal expansion and not from animal productivity increases. Horizontal expansion results in cattle gradually being displaced to more marginal land.

There is extremely rapid urbanization and the rural population declined from 50-60 per cent in various countries of the region in 1960 to 10-40 per cent in 1990. Milk production has not kept pace with demand and urban growth. Meat production exceeds local demand and allows considerable exports but regional consumption per caput shows a downward trend. Low land prices allow production systems to remain extensive in nature and there is little pressure to intensify in many areas. Price policies have focused on urban consumers and this has been assisted by subsidized prices of imports from the European Union. Prices paid to consumers have remained low.

Tasks Two and Three

Priority areas are the **humid, subhumid and semiarid lowlands** and the **highland** agroecozones. The goal is the sustainable improvement of the welfare of people and the environment, which can be described as ecosystem health. The main **purposes** in achieving ecosystem health are to optimize the contribution of livestock to the national economy and welfare, increase livestock productivity, and maintain or enhance the natural resources and biodiversity in the context of livestock production systems. Each purpose has an accompanying set of **outputs** and these in turn are achieved by a group of **activities**. Outputs expected from optimized livestock contributions are improved farm income and better rural development, improved health and welfare of the rural and urban poor, improved livestock markets and better conditions for research on crop/livestock systems. Optimized feeding strategies, improved animal health, selected and appropriate species and breeds, an improved understanding of the role of livestock in mixed farming systems, better training and education programmes and improved product quality and processing methods are the outputs expected from the increased livestock productivity purpose. Maintained or enhanced natural resources and biodiversity are expected to result in improved soil fertility, stabilization of hillsides and reduced erosion, and reduced deforestation and smaller areas of slash and burn agriculture.

Final Plenary Session

Discussion

The discussion centred largely on points requiring clarification in the presentations by the three working groups. General comments covered the costly and not very successful farming systems approach in sub-Saharan Africa but it was felt that this criticism of on-farm research was probably premature as the real objectives and problem definitions were not sharp enough and lead to the collection of costly and unnecessary data that were not analyzed or, if they

were, contributed little to the removal of the ill-defined constraints. A further comment on research failure related to the lack of a genuine needs assessment of rural farmers, insufficient attention being paid to an ecosystem approach and the hierarchy of nested ecosystems that comprise the animal production system.

It was also considered that widespread support for helping people in low income countries through livestock development needed some institutional structure based on sustained allocation of funds and manpower. There was also considered to be a need for a mechanism that takes into account the concerns of the public, interest groups and policy makers in developed countries and that a global forum, a secretariat, a policy network and a "2020 vision for livestock" would be complementary activities in this mechanism. Attention was also drawn to the fact that publicizing the role of livestock and promoting policy research would cost money. Funding might have to be a consortium effort.

Finally, policy was highlighted as important but it was accepted that this is swayed by politics, external funding, resource allocation, interest lobbies and many other factors. Livestock were considered to make a major yet still undervalued contribution to development. The answers coming out of this meeting and the constraints and opportunities identified must be exploited for the benefit of livestock development and the welfare of the world's people.

Peroration

The main point arising from the Roundtable is that the welfare of small farmers and herders - and not of livestock - is the goal. Livestock research and development must turn the goal into reality. Livestock's case must therefore be presented to show that improved production will not adversely affect opportunities to feed people, maintain environmental quality and conserve genetic resources.

The new vision places livestock in a production and an ecological system. There are immense opportunities to improve producer and consumer welfare by further integration of crops and livestock into truly mixed systems. This new system thinking presents a challenge. Experts in systems analysis and modelling need to be brought into livestock research fora. A critical factor for further progress will be a clear articulation of the role of livestock in advancing human development.

Understanding of the consequences of continuing with the *status quo* versus the pursuit of visionary but realistic alternatives must be developed as part of the process. A capacity to create development scenarios and policy alternatives has been identified as a need, requiring the blending of Global Information Systems and modelling with policy analysis techniques. The resultant framework should show where livestock can make a difference. It could form the basis of a set of research and policy decision support systems for use by international, national and local organizations.

Progress in the development of realistic scenarios needs to be supported by research on indicators of performance - ecosystem health - so that the models can be simple and persuasive. Research on indicators will also be useful in clarifying the relations between livestock and the environment.

One of the greatest openings for progress lies in the identification of opportunities to improve livestock policy and the institutional arrangements that influence livestock management and investment strategies. Land tenure arrangements, for example, can give investment security and facilitate joint management of resources. New price and regional trade policies would do much to improve overall welfare and reduce land degradation. As some reforms would bring about significant structural adjustment it is important that the most effective order or sequence for implementing change is identified. Simple generalized recommendations that fail to clarify

the impact of change are insufficient and only serve to discredit livestock research.

Past research agendas have failed to involve local farmers. Isolated behind field station gates much research has seemed, and on examination has proved, to be irrelevant. Research projects that focus on problems that are not relevant to farmers' needs risk failure. The alternative is a research environment that creates a seamless link between resource use, people, development, extension and research. Development projects can be modified to provide the adaptive platforms necessary for effective research. Animal breeding trials and forage utilization trials can be carried out on farms.

The search for new research mechanisms suggests a parallel need for research on ways to encourage local communities to solve their own problems, to form their own organizations and, even, to commission research. Overall the vision is one that is output and product focused with people at the centre. Problem recognition, firm product targets, clear hypotheses, system thinking, policy relevance and small farmer welfare provide focus for that vision.

Recommendations

The livestock roundtable concluded its meeting with optimism and purpose. In particular, it felt that the new vision of livestock research and development working in partnership must result in the development of an action plan. It resolved unanimously:

- that senior representatives from FAO and ILRI meet before May 1995 to form a **Livestock Research and Development Forum** with a charter to
 - coordinate livestock related research and development across the developing world,
 - identify opportunities to create synergies between development and research by, for example, targeting work in the same region and designing projects so that they can be used for complementary research and development purposes,
 - ensure that research conclusions are incorporated into development proposals as soon as possible,
 - act as a clearing house for information about livestock development and research proposals,
 - facilitate the refinement of draft project plans by means of appropriately constructed working groups,
 - endorse integrated development/research plans for submission to donors,
 - promote livestock's image in development and the potential for research on livestock production and resource conservation to enhance their positive contribution to sustainable development, and
 - identify opportunities for the development of innovative livestock communication strategies.
- that FAO/ILRI/IFPRI develop a proposal for a **Livestock Policy Research Network** for submission to the livestock planning group responsible for implementing the CGIAR's new Systemwide Livestock Initiative.

- that ILRI, in association with FAO, take a lead role in developing the image of livestock, livestock research, and livestock development.
- that ILRI ensure that the new CGIAR communication strategy give prominence to livestock research.

It is anticipated that the **Executive** of the **Livestock Research and Development Forum** would comprise a small group of FAO and ILRI representatives responsible for the general direction of livestock research and development. The opportunity to expand the Executive to include people from other agencies, NARS and farmer organizations should be considered. The Executive would be aided by a **Secretariat** comprising senior staff of FAO and ILRI. One or two resource persons could be appointed to the Executive and/or the Secretariat. Opportunities to allow open membership of the forum and hold periodic meetings should be considered carefully. It is envisaged that the forum's Executive would meet at least once a year and, through its Secretariat, convene regularly by e-mail.

Introduction

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Background to the Roundtable

The Roundtable on Livestock Development Strategies for Low Income Food Deficit Countries was a joint undertaking between the Food and Agriculture Organization of the United Nations and the International Livestock Research Institute¹. The initiative originated from informal discussions between staff of the Animal Production and Health Division (AGA) of the Agricultural Department of FAO and ILCA (as it was then) personnel. A tentative programme and speakers were then decided and FAO provided funds under a Letter of Agreement for ILRI to undertake all the practical arrangements, including providing international travel for participants. FAO provided, in addition, the services of an experienced writer and resource person for compiling and editing the Proceedings.

¹ This and the next section draw largely on the Welcome Address given on behalf of FAO by Juhani Maki-Hokkonen

The preparatory work was undertaken by the ILRI Organizing Group. They are to be congratulated for their courage in deciding that it should directly follow the inaugural Board meeting of the new institution now known as the International Livestock Research Institute which combines the infrastructure and human and technical resources of the two previously independent centres, the International Livestock Centre for Africa and the International Laboratory for Research on Animal Diseases.

This brave decision enabled board members to contribute to the Roundtable: some as main speakers; others as moderators; and all as active participators. The presence of board members and renowned experts with vast experience in livestock development from Asia, Africa, the Americas, Australia and Europe acting as speakers and resource persons greatly increases the chances that the recommendations will be rapidly adopted by the international community. This is especially important for the time is opportune, with attention focused on the newly established ILRI, to put livestock back on the world stage where they rightfully belong. It is also important that the recommendations and rationale for development arising from the Roundtable reach the widest possible audience of policy and decision makers. The rapid appearance of these Proceedings is an attempt to facilitate this process.

It is hoped that this Roundtable will mark the beginning of a period of greater cooperation between FAO and ILRI and with all the institutions and organizations represented. It should also result in a more rational and efficient use of scarce resources. An earlier Consultation hosted by ILRI in January 1995 to discuss A Global Agenda for Livestock Research complements this Roundtable (see Annex I). A further companion meeting organized jointly by FAO/WAAP will take place in May 1995 in Korea to discuss issues relating to the supply side

of livestock products, especially to urban consumers (see Annex II).

Work programme and thrust of the Animal Production and Health Division of FAO

In January 1994, the newly appointed Director General of FAO initiated a major restructuring of the whole organization and its programme. Food security and sustainable agricultural development were chosen as the main development objectives of the Food and Agriculture Organization, with particular emphasis being given to Low Income Food Deficit Countries.

This was an opportunity for AGA to assess both the structure and focus of its own work critically. An internal informal Working Group of six professional staff undertook an assessment of the old programme and produced a proposal for a newly structured programme more responsive to FAO's new initiatives and their implementation.

The exercise was a truly "preparatory process" that included almost continuous discussion and interaction among staff. The timing was critical as the results needed to be included in the Programme of Work and Budget for the 1996-1997 biennium

Two major documents were produced as a consequence of the internal review:

- Final Report of the Working Group on "Restructuring of the AGA Livestock Programme"; and
- an AGA Staff Working Paper "Livestock: A Driving Force for Food Security and Sustainable Development"²

² Compiled and edited by Rene Sansoucy, Senior Officer of the Feed Resources Group of AGA. The Keynote Paper in these Proceedings draws largely on that document. A related paper was "Livestock for Food Security - Technology Options for Inclusion in Food Security Projects" compiled by AGA staff member Simon Mack, who was also the driving force behind the Working Group's Final Report.

After much discussion a general consensus was reached on all important issues and AGA will have a new programme for the 1996-1997 biennium. This will be based on an integrated systems approach rather than the former structure which has been based on the classic focus by technical discipline. The six subprogrammes of the new Programme will be:

- information systems, policy and planning;
- periurban systems;
- mixed farming systems
- pastoral and extensive grazing systems;
- animal genetic resources; and
- transboundary animal diseases.

Cross-disciplinary Task Forces rather than individual specialists will be responsible for planning and implementing subprogramme elements and activities. Development issues in each subprogramme will be treated on-farm, off-farm, nationally and globally. On-farm problems of livestock development will be approached in an agroecoregional framework.

More detailed programming of the technical elements and activities of the internal planning cycle has not yet started. The outcome and recommendations of this Roundtable will be particularly relevant for there exists a realistic opportunity to adopt them, at least in part, into

AGA's Regular Programme for the next biennium and into ILRI's new global focus.

The International Livestock Research Institute

The International Livestock Research Institute (ILRI) came into being as a new institute on 1 January 1995³. ILRI is an amalgam of the former International Livestock Centre for Africa, based in Ethiopia but with several field stations in the various agroecological zones of Africa, and the International Laboratory for Research on Animal Diseases, which had its headquarters in Kenya. The concept, status and mandate of the new centre result from early recommendations by the Technical Advisory Committee of the Consultative Group on International Agricultural Research followed by long discussions and decisions by high level Task Forces and committees with members drawn from several disciplines and from all corners of the globe.

³ This sections draws on the Welcome Address given on behalf of ILRI by Hank Fitzhugh

ILRI continues the work of its two contributing institutions and can draw on two times twenty years of accumulated experience⁴ of animal health research on the one hand and of biological, agroecological and socio-economic research on the other. ILRI has a global mandate to:

- improve animal performance through generating technology and conservation of animal (and plant) genetic resources;
- improve and sustain production systems;
- improve the technical and economic performance of the livestock sector; and
- transfer technology and information to national programmes and institutions.

⁴ For more details of the work done by the two founding institutes see their various Annual Reports and Programme Highlights. In particular see: ILCA 1994 *"Twenty years of livestock research, 1974-1994"*; and ILRAD 1992 *"Meeting the challenge of livestock diseases, ILRAD moves towards the 21st Century"*.

New programmes will complement the major thrusts inherited from the founding institutions. The new programmes are still being developed in detail but are likely to include some or all of:

- Animal health improvement
 - trypanosomiasis
 - tick borne diseases
 - helminthiasis
- Conservation and use of biodiversity
 - animal genetic resources
 - plant genetic resources
- Production systems and resource management
 - system modelling and impact assessment
 - system analysis in ecoregions

- use of feed resources and rumen ecology
- Livestock policy analysis

In addition to ILRI, centres in the CGIAR system that have livestock or related programmes include CIAT, ICARDA, ICRAF and IFPRI. The CGIAR system is currently working on a "Systemwide Livestock Initiative" that is intended to harmonize the approach to livestock by the various centres. As the only specialist centre on livestock in the system ILRI is coordinating the SLI document for the Technical Advisory Committee.

Objectives and expected outputs of the Roundtable

Major development objectives

The primary objectives⁵ of the Roundtable were to:

- provide a forum for senior livestock scientists and developers for the exchange of views and experiences; and
- raise the level of awareness of a far wider and influential audience with regard to the potential and the constraints facing animal agriculture in low income countries.

⁵ This sections draws on the initial presentation of Simeon Ehui, who was the principal organizer of the Roundtable at ILRI

Specific immediate objectives

The immediate objectives of the Roundtable were to:

- review the contribution and potential of livestock to increase sustainable food production, and contribute to income generation in low income countries with a forward perspective to 2020 ("The Global 2020 Vision for Livestock");
- identify major social, economic, technical and institutional constraints limiting livestock's contribution to achieving food security and economic development; and
- define appropriate strategies to alleviate these constraints and propose a framework for international action to enhance animal productivity in its broadest sense.

Expected outputs

The expected outputs of the Roundtable were:

- an analysis of past and present trends in livestock productivity and consumption of livestock products which would be used in part as an input to a "2020 Vision" paper to be further developed after the meeting;
- a statement of a defined set of objectives within the time frame specified and a related description of the constraints that must be overcome for the objectives to be achieved; and
- formulation of the set of measures ("a framework for action") or strategies needed for increasing livestock productivity in low income countries and securing better management of the natural resource base from the present to the end of the second decade of the 21st century.

Organization

The Roundtable was organized around four sessions.

Session One started with a Keynote paper and two other background papers were presented to set the scene for the remainder of the programme.

Session Two comprised two detailed papers which dealt in depth with major issues, constraints and opportunities for development.

Session Three drew on the expertise of scientists and field workers to present a series of five papers covering the options for increasing livestock's contribution to human welfare from the world's major production systems and agroecological zones.

All three sessions included discussion periods following the presentation of each paper and a fuller discussion of all papers together before the session closed.

The last part of the meeting, Session Four, consisted firstly of detailed discussions by participants who were split into three Working Groups covering: sub-Saharan Africa and West Asia and North Africa; Asia; and Latin America and the Caribbean. Secondly, the conclusions and recommendations of these Working Groups were then presented in a Plenary Session, again discussed and then formed the basis of the final presentation and recommendations of the Roundtable.

Part One: Background papers

Moderator

Juhani Maki-Hokkonen

Rapporteur

Mohammed Jabbar

Keynote paper: The contribution of livestock to food security and sustainable development

Development support and livestock

Impact of human activities and livestock on the African environment: an attempt to partition the pressure

Discussion sessions: Part One

Keynote paper: The contribution of livestock to food security and sustainable development¹

R Sansoucy - Food and Agriculture Organization, via delle Terme di Caracalla, 00100 Rome, Italy

M A Jabbar, S Ehui and H Fitzhugh - International Livestock Research Institute/P O Box 5689, Addis Ababa, Ethiopia

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¹ This paper is a revised and extended version of "Livestock - a driving force for food security and sustainable development" by R Sansoucy and staff of the Animal Production and Health Division of FAO

Introduction

Between 1960 and 1990 the world's human population increased by 75 per cent from 3.1 billion to 5.4 billion but developing country populations increased by 97 per cent from 2.097 billion to 4.138 billion (FAO, 1992). Food grain production per caput during the same period increased from 310 to 375 kg overall but from 190 to 260 kg in developing countries. In the late 1970s, 45 developing countries were unable to assure adequate food energy needs of 2200 calories per person per day for their populations and 25 of these countries were still in the same position in the late 1980s (Pinstrup-Andersen, 1994). There are now 800 million people suffering from malnutrition and hunger, not only due to insufficient production and inadequate distribution but also because the poor lack the income to acquire food of adequate quantity and quality to satisfy their needs (FAO, 1993a).

The world population is projected to increase from 5.4 billion in 1990 to about 7.2 billion in 2010. This increase will occur mainly in the developing countries and in urban areas and will have major effects on patterns of food production, marketing and consumption. Strategies are needed to ensure food security for the growing population, to increase income, to support economic development, and to protect the environment.

Livestock production is a major component of the agricultural economy of developing countries and goes well beyond direct food production. Sales of livestock and their products provide direct cash income to farmers. Livestock are the living bank for many farmers and have a critical role in the agricultural intensification process through provision of draught power and

manure for fertilizer and fuel. They are also closely linked to the social and cultural lives of millions of resource-poor farmers for whom animal ownership ensures varying degrees of sustainable farming and economic stability. Official statistics often underestimate the overall contribution of livestock and especially their multipurpose contributions to food and agricultural production in developing countries.

This paper considers both direct and indirect contributions of livestock to food security and sustainable development in the developing countries.

The meaning and scope of food security

The meaning of food security has evolved since the first World Food Conference of 1974. It is now accepted that it relates to access by all people at all times to enough food for an active healthy life (Reuntlinger, 1985; World Bank, 1986; FAO, 1989) but the concept is used differently at different levels.

At regional and national level it is equated with national or regional balances, i.e. between availability and need based on assumed per caput need. At household level, food security is equated with sufficiency of household entitlements - that bundle of food production resources, income available for purchases, and gift or assistance sufficient to meet the aggregate needs of all household members. Achieving food security in this case is largely determined by an assumption of minimum nutritional need. Security at the level of the individual is rarely, if ever, considered (Chen and Kates, 1994).

Irrespective of the reference level, food balance is now considered an inadequate criterion for food security because availability may not guarantee access due to poor distribution or lack of purchasing power. There are many examples of coexistence of aggregate food self-sufficiency and widespread malnutrition and hunger. Food security is therefore defined by a combination of criteria that are not mutually exclusive (Chen and Kates, 1994), as:

- balance between availability and need;
- absence of famine or temporary food insecurity;
- seasonal or chronic undernutrition;
- micronutrient deficiency, especially iron, iodine and Vitamin A; and
- nutrient-depleting illness such as malaria, diarrhoea and internal parasites.

In theoretical and empirical literature food security is defined with reference to food grains. This is especially misleading for societies where roots and tubers are major sources of food and income and for mainly pastoral or livestock-based societies where livestock products are important sources of food and income (Anon, 1989). For example, foods other than cereals supply 40 per cent of total food energy for half of the sub-Saharan African population with the highest risk of food insecurity (FAO, 1993b).

In this paper, the potential contribution of livestock to food security and economic development is assessed in relation to other functions. Exclusion of livestock is inappropriate because individual and household food security depends on access to assets, work and assured income. Livestock may contribute to food security through increased output of livestock and non-livestock products and by employment and income generation that may assure access to food.

Livestock and food supply

If food security is defined as "...access to enough food for an active healthy life" livestock can make a major contribution. An adequate quantity of balanced and nutritious food is a primary

indicator of quality of life, human welfare and development. Animals are an important source of food, particularly of high quality protein, minerals, vitamins and micronutrients. The value of dietary animal protein is in excess of its proportion in diets because it contains essential amino acids that are deficient in cereals. Eating even a small amount of animal products corrects amino acid deficiencies in cereal-based human diets, permitting more of the total protein to be utilized because animal proteins are more digestible and metabolized more efficiently than plant proteins (Winrock, 1992, De Boer *et al*, 1994).

"Quality foods ... derived from animal sources have major importance for optimizing human performance in chronically mild to moderately malnourished populations" (Diaz-Briquets *et al*, 1992). This is especially important for young children.

In 1990, per caput consumption of meat, milk and fish in developing countries was 22, 18 and 33 per cent of that in developed countries (Table 1). Between 1962 and 1987, consumption of energy, protein and fats from livestock products increased 23 times faster in developing than developed countries (Table 2). Yet absolute levels of consumption of these nutrients in 1987 were nearly five times higher in developed than in developing countries.

Table 1 Per caput consumption of meat, milk and fish in 1990 (kg/year)

Region	Commodity		
	Meat	Milk	Fish
World	32.9	75.0	13.1
Developed	81.6	200.0	26.8
Developing	17.7	36.6	8.8
Africa	11.4	27.5	8.0
Latin	41.1	93.9	8.6
Near East	19.6	60.7	4.4
Far East	15.1	27.0	9.4

Source: FAO, 1992

Table 2 Per caput consumption of energy, protein and fat from livestock products in developed and developing countries, 1962 and 1987

Year	Developed countries			Developing countries		
	Calories cal/day	Protein g/day	Fat g/day	Calories cal/day	Protein g/day	Fat g/day
1962	859	44.9	66.1	138	8.4	9.9
1987	1034	59.4	79.0	226	13.2	16.8
% change	20.4	32.3	19.5	63.8	57.1	69.7

Source: FAO, 1992

Developed countries increased already high levels of consumption through slower population growth and rapid increases in livestock productivity by use of improved technology. Developing countries failed to bridge the gap in consumption in spite of a much more rapid increase in all categories of livestock (Table 3). In order to meet increased demand, developing countries imported increasing quantities of animal products, particularly dairy products (Figure 1a). There is a balance in aggregate imports and exports of meat (Figure 1b) but exports are primarily from a few developed countries while many developing countries are importers.

Table 3 Human and livestock populations (millions) in developed and developing countries, 1960 and 1990

Item	Developed countries			Developing countries		
	1960	1990	% change	1960	1990	% change
People	977	1251	28	2097	4138	97
Large ruminants	343	404	18	692	1029	49
Small ruminants	573	591	3	792	1217	54
Pigs	235	341	45	171	515	201
Poultry	2274	4465	96	1648	6305	283

Source: FAO, 1992.

Figure 1: Value of dairy and meat imports and exports in developing countries, 1961-1989

Figure 1a . Dairy

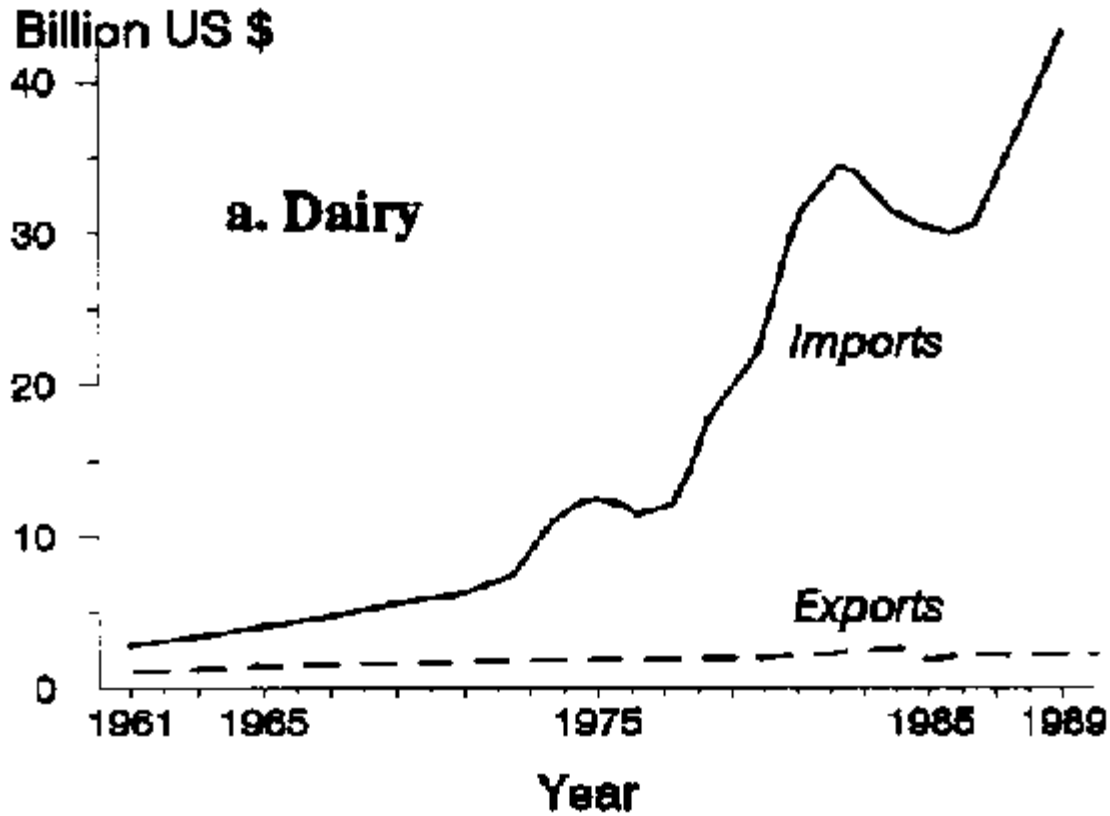
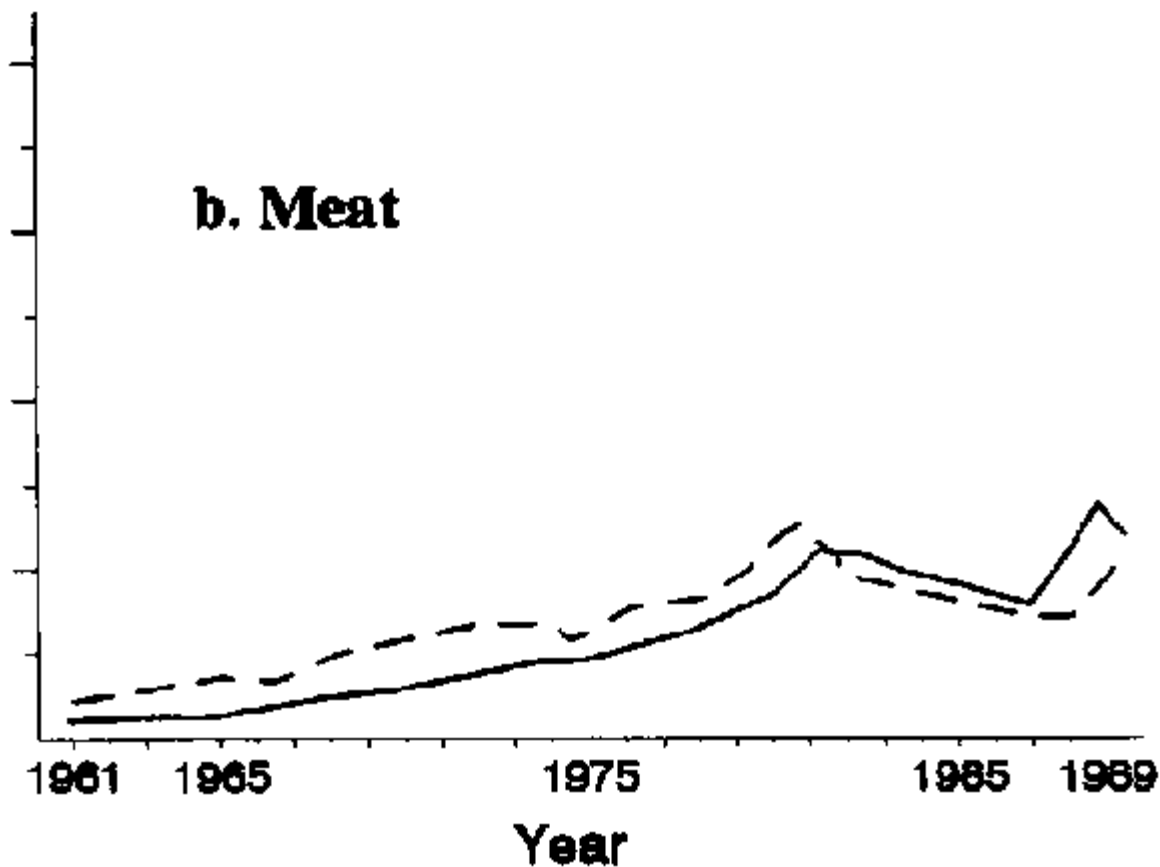


Figure 1b. Meat



Increased livestock production in developing countries may add to food security in several ways.

First, many poor small holders will have direct access to more food of livestock origin.

Second, increased production will keep livestock product prices down and allow low income groups access to such food. Producers should gain in the face of lower prices because livestock products are both price and income elastic, so lower prices should increase demand, total production and farm revenue. In many countries, low income people suffer more from energy than they do from protein deficiency. Increased production and low prices may allow consumers on low incomes to increase consumption of livestock products and help overcome the energy-protein deficiency simultaneously (Lipton, 1988).

Third, increased domestic production will reduce imports and save foreign exchange which can then be diverted to productive investment and indirectly contribute to food security. Some countries generate revenue by taxing imported goods including animal products. Taxing increased income from domestic production may serve the same purpose.

Livestock as a source of income

Animal products are a source of disposable income for many small farmers in developing countries. In fact, livestock are often the most important cash crop in many small holder mixed farming systems. Disposable income is important for purchase of agricultural inputs and other family needs.

The first five of 45 ranked agricultural commodities in developing regions are rice, milk, wheat, beef/buffalo meat and pig meat. Eggs, poultry meat and sheep/goat meat rank 9, 20 and 21 (FAO quoted in TAC/CGIAR, 1992). On a global basis meat, milk, eggs and fibre together

contribute about 40 per cent of the total value of crop (excluding trees) and livestock (excluding fish) production. The proportion is about 50 per cent in developed areas and 25 per cent in developing regions (USDA, 1990, quoted in Fitzhugh, 1993). If trees and fish are included in the definition livestock account for 19 per cent of all agricultural commodities in the developing regions as a whole but the share is up to 25 per cent in Latin America and the Caribbean and West Asia and North Africa (Table 4). These figures do not include the values of draught power and manure, and the contribution from equines, camels, yak and other minor livestock species. Adding these would further increase the proportional contribution of livestock in developing regions. In sub-Saharan Africa including non-food products and services would increase livestock's contribution by 50 per cent (Winrock, 1992).

Table 4 Relative importance of livestock products in developing regions, 1987/1989

Commodity group	Region				
	Asia	Sub-Saharan Africa	Latin America and Caribbean	West Asia and North Africa	Total
All commodities (US\$ billion/year) per cent share of	379	66	145	48	638
Crops	59	53	51	69	57
Livestock	17	15	25	25	19
Trees	19	29	17	4	19
Fish	5	3	7	2	5

Source: FAO quoted in TAC/CGIAR (1992).

At farm level, the importance of livestock as an income source and the actual sources of income vary across ecological zones and production systems, which in turn determines the species raised and the products and services generated. Cash can be generated from sales of livestock products regularly (milk, eggs) or sporadically (live animals, wool, meat, hides) or from services (draught, transport). Dairy produce is the most regular income generator. Dairy development has been shown to increase income, consumption and repayment capacity in India (Kulkarni *et al*, 1989; Saini *et al*, 1989).

In densely populated Bangladesh, cattle fulfil multiple roles in generating income and ensuring food security. A survey in a periurban area and a remote village showed average land holdings in the former to be half of the latter but average cattle holdings were only marginally lower (Table 5). In the remote village 78 per cent of cows were dual purpose compared to 48 per cent in the periurban area. Average milk yield of draught cows was about 60 per cent of non-draught ones, yet farmers used cows as they did not have enough cash to buy bullocks nor enough feed to maintain both bullocks and cows.

Table 5 Land and cattle holdings and milk sales in a periurban and a remote village in Mynensingh district, Bangladesh

Item	Periurban village	Remote village
Sample households	100	100
Average land holding, ha/household	0.70	1.30
Number of cattle per household		
Bullocks	1.02	1.28
Cows	1.21	1.23
Young cattle	1.58	1.70
Total	3.81	4.21

% cows used for draught	48	78
Highest daily yield/cow (litre)		
Draught + milk cow	1.40	1.40
Milk cow	2.35	2.42
% households selling milk		
Entire output	51	36
Part of output	27	40
None	22	24

Source: Jabbar and Ali, 1988.

Crop production of such farmers would suffer without using cows for draught. About 77 per cent of households in both the villages sold part or all of the milk output to supplement income from crop and other sources. A higher proportion of households in the periurban village sold all their milk indicating that a high value nutritious food was given up to meet other family needs (Jabbar and Ali, 1988).

The importance of livestock as a source of income for poor farmers in Bangladesh is illustrated by the fact that the Grameen Bank, which assists the "poorest of the poor", provides nearly 50 per cent of its loans for the purchase of livestock, mainly large ruminants for milk production and fattening for sale (Hossain, 1988).

In small holder crop-livestock systems in the Ethiopian highlands livestock accounted for 34-87 per cent of total cash income from crops and livestock. Crops are more often a subsistence enterprise. The livestock share in cash income was higher in those villages where total cash income was higher indicating that increased cash income came primarily from livestock (Gryseels, 1988; Asamenew, 1991; Omiti, 1995). In semiarid Mali, livestock contributed 78 per cent of cash income from crops and livestock on small holder mixed farms (Debrah and Sissoko, 1990). In both Ethiopia and Mali, a major part of livestock cash income was spent on food and medicines. In some crop-livestock systems, such as in semiarid areas of Botswana, self-sufficiency in food crop production may not be a major goal. Most food crops may be purchased by income generated by livestock. In a similar environment in a different place, as in northern Nigeria, farmers may place heavy emphasis on self-sufficiency in food crop production because food grain supplies cannot be reliably obtained through the market (Norman *et al*, 1988).

In many societies, women have specific family responsibilities and ownership of livestock and access to livestock products for sale helps them in these functions. In southern Nigeria 41 one per cent of 5460 sales of small ruminants in four village markets over a period of 14 months were by women. Although both male and female sellers sold primarily for cash needs (55 per cent of sales), cash needs for buying food and clothing were a more prominent reason for sale by women (Jabbar, 1995).

Livestock give increased economic stability to farm households, acting as a cash buffer (small stock), a capital reserve (large animals) and as a hedge against inflation. In mixed farming systems, livestock reduce the risk through diversification of production and income sources and there is therefore a much greater ability to deal with seasonal crop failures and other natural calamities. Livestock represent liquid assets which can be realized at any time, adding further stability to the production system.

Livestock as generators of employment

Increased production implies higher employment. Dairying is labour intensive at farm level and

women are active in production and marketing. Labour typically amounts to over 40 per cent of total costs in small holder systems. It is estimated that each 610 kg per day of additional milk processed in India adds one man-day for feeding and care. In Kenya small holder systems, processing of 25 kg adds one man-day and similar levels were seen on parastatal dairy farms in Zimbabwe. Goats, sheep, poultry and rabbits, and especially from backyard production systems, are an important source of part-time work, particularly for landless women and children.

The processing sector has also been identified as a focus for generating employment and limiting rural depopulation. Small scale milk processing and marketing is labour intensive (50-100 kg per workday) and generates employment (and income) from local manufacture of at least part of the equipment used. The meat sector also provides employment for slaughter, marketing and processing (Table 6).

Table 6 Labour needs for processing and marketing for 30 head of stock

Animal species	Labour need (person/day)		
	Slaughter	Marketing	Further processing
Cattle	20	4	> 80
Pig	10	2	> 30
Small ruminants	3	1	n.a.

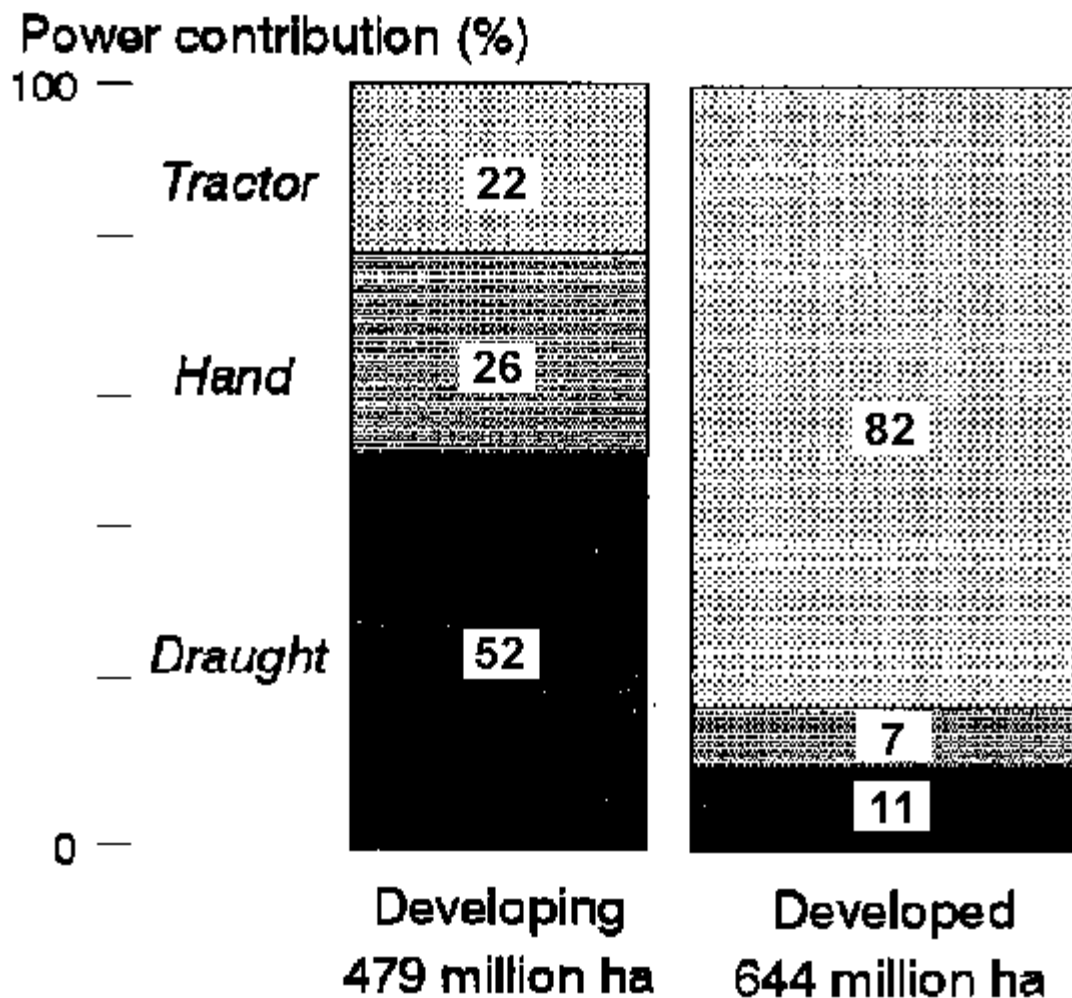
Source: FAO, unpublished data

Livestock as suppliers of inputs and services for crop production

Draught power

Bovines, equines, Camelidae and elephants are used in draught operations as diverse as pulling arable implements and carts, lifting water and skidding logs. The number of animals used for draught is estimated at 400 million. About 52 per cent of the cultivated area in developing countries (excluding China) is farmed using draught animals against 26 per cent with hand-tools (Figure 2). During the past ten years there has been a 23 per cent increase in the numbers of cattle and buffalo used for draught as well as meat and milk production. At the same time the number of equines used primarily for draught and transport has not significantly changed.

Figure 2 Livestock use in draught animal power, in developing and developed countries in 1992



It is expected that draught animal use will decline slightly by the year 2000 in all regions except Africa. In Latin America and the Near East, tractor use will increase slightly while use of human power will increase slightly in Asia (Alexandratos, 1988). In areas such as semiarid and subhumid West Africa, where crop-livestock mixed farming is evolving and expanding, increased use of animal traction will help intensification and contribute to higher output and income (McIntire *et al*, 1992) and therefore to greater food security. In the 1960s and 1970s, rapid urban and coastal economic growth encouraged migration from the Sahel and increased the opportunity cost of using cattle for traction. In recent years, however, this cost has been decreasing due to coastal economic stagnation and it is likely that the situation is now more conducive to development of mixed farming and increased use of traction in the inland countries (Delgado, 1989).

At farm level, draught animal ownership patterns have implications for food production and security. There are positive correlations between draught animals and cereal crop production (Gryseels, 1988; Omiti, 1995). In many developing countries ownership is skewed. Many small and marginal farmers own none or an inadequate number of traction animals (BBS, 1986; Gryseels, 1988; Asamenew, 1991). Crop production of these farmers suffers due to late planting, poor quality tillage, use of low value crops needing less tillage and an inability to cultivate all available land. These problems may be aggravated after natural calamities such as flood or drought due to death or poor health of animals and increased draught animal prices (Jabber, 1990).

Draught power economics are improved if one animal is used instead of two and if a cow is used instead of a male. This strategy reduces the cost of maintaining the larger herd necessary to satisfy replacements and milk production. Draught cows need, however, to be

given additional feed if milk production and reproduction are not to be affected.

Manure

Nutrient recycling is an essential part of any strategy for sustainable agriculture. Integration of livestock and crops allows for efficient recycling through use of crop residues and by-products as animal feeds and for animal manure as crop fertilizer. Cattle dung contains about 8 kg of nitrogen, 4 kg of phosphate and 16 kg of potash per tonne of dry matter (Ange, 1994). In addition, manure returns organic matter to the soil, helping to maintain its structure as well as its water retention and drainage capacities

Throughout the developing world, manure is the primary source of plant nutrients for traditional rainfed crops. Chemical fertilizers are expensive and applied mainly to high yielding varieties especially in irrigated conditions. A massive currency devaluation in the West and Central African Francophone countries in 1993 increased prices of fertilizers so much that farmers responded by applying more manure, by making compost in a systematic manner and by developing a market for manure (Sanders *et al*, 1995).

In areas where crop-livestock mixed farming is emerging manure is an important link. Manure is of paramount importance in these areas because most soils are fragile and of low inherent fertility. Only a small fraction of crop land receives adequate manure, however, and availability in a given year depends on the livestock population and its species composition, location at manuring time, feed supply from range and crop land and efficiency of manure collection. Since crop and livestock production are not yet integrated on a wide scale, there is considerable loss of nutrients in the process of transfer from range-based livestock to crop fields. Nutrient flow may be further affected by drought-induced changes in livestock populations, species composition and animal mobility. For these reasons, it has been estimated that, in present production systems, animal manure is not adequate to sustain the current level of crop production in the semiarid areas because it requires a very high pasture area per unit of crop area (Fernandez-Rivera *et al*, 1994; McIntire and Powell, 1994; Williams *et al*, 1994).

This is probably an interim problem because population pressure and market conditions will drive intensification in the future and crops and livestock will be more integrated. Loss of manure will then be minimized as it becomes critical for sustaining soil productivity. It has also been suggested that efficiency of manure use can be increased by joint application of manure and fertilizer and manipulation of the relative amounts and times of application of manure (Brouwer and Powell, 1994; Murwira *et al*, 1994). Improved feeding, such as using urea-treated straw, improves manure quality which in turn gives higher crop yields. It is recognized, however, that achieving higher productivity in agriculture will require increased use of chemical fertilizers.

Dung for fuel and biogas

In many countries dung is valued as fuel for cooking and heating and for reducing expenditure for fuel wood or fossil fuels. It represents the major fuel for household use by millions of farmers in Asia and Africa and in parts of the Near East and Latin America. In India, 300 million tonnes of dung are used for fuel every year. The collection and drying of dung for cooking generates income for women. It is also used as plaster and as a building material.

In an historical context, use of dung as fuel is a recent phenomenon prompted mainly by scarcity of fuel wood and represents a loss to plant nutrition. An individual household in a given situation tries, however, to maximise its use by allocations between manure and fuel and by taking into account the trade-off between the two. Unless chemical fertilizer can adequately compensate the use of dung for other purposes, this competition may negatively affect food

production and food security in some situations. Biogas production may be a viable alternative to reduce competition between fuel and manure use.

Biogas from manure is an excellent substitute for fossil fuel or fire wood. The best sources for these purposes are (in descending order) pigs, cattle, horse, camel, poultry (Kumar and Bisas, 1982). About 1 m³ of gas is produced from 25 kg of fresh cattle dung. Simple low-cost plastic biodigesters have recently been developed by a number of FAO/TCP projects, for example in Cambodia, Tanzania and Vietnam. Biogas production on the farm reduces the workload of women by eliminating wood collection or the purchase of fuel. It is woman-friendly because of convenience, increased hygiene and the supply of services such as lighting, warm water and heating. Biogas can also be used to drive machinery such as water pumps.

Effluent from biodigesters can be recycled as fertilizer, with even better results than the original manure (Talukder *et al.* 1988), as a fish feed, or to grow azolla and duckweed. Biodigestion has positive public health aspects, particularly where toilets are coupled with the biodigester, and the anaerobic conditions kill pathogenic organisms as well as digesting toxins such as botulinum. Biogas from dung has also been used in China (Zhin and Pan, 1983) to control insects in stored grains, using the anaerobic reaction, without adverse effects on grain germination. Biogas technology is being successfully adopted by millions of farmers - about 25 million people use it in China alone - in developing countries (Marchaim, 1992).

Weed control

Livestock, particularly sheep, are efficient in controlling weeds and thus help to increase crop production. They are used in many countries in the Mediterranean basin to reduce forest undergrowth in order to reduce fire risk during summer. In Malaysia, it has been shown that, in rubber and oil palm plantations, the use of livestock on the ground cover under the tree canopy increases overall production and can save up to 40 per cent of the cost of weed control (Chen *et al.*, 1988). Sheep have also been used to control weeds in sugar cane fields in Colombia (Carta Asolucerna, 1993), lowering the cost of herbicides, reducing by half the total cost of weed control and providing an additional income from meat production. Such systems also safeguard the environment and avoid chemical pollution while supplying additional organic material to the soil.

Recycling own secondary products and household and industrial wastes

Manure can be a valuable source of feed for other animal species and poultry manure is commonly used for ruminant feeding. Poultry and pig manure can also be used to generate algae as a feed for fish.

By-products such as slaughterhouse wastes, when adequately processed, are useful protein (offals and viscera) and mineral (bones) supplements in animal feeds. Household wastes are commonly fed to pigs and small animals in backyard systems in developing countries. In urban and periurban areas, restaurant and catering wastes can easily be processed for pigs.

Industrial fish waste creates pollution around canning plants. It is usual to dry it, at very high cost, for fish meal for export to developed countries. Preservation of fish waste in molasses for feeding has been shown to be technically and economically feasible for use by poor farmers.

Livestock production, resource management and environmental degradation

In recent years, the importance of animals as an efficient and economic means of food production has been challenged, as have their effects on the environment. These concerns are predicated on a number of issues, prominent among which are:

- competition with alternative land use, and between using cereals (and some roots and tubers) as animal feeds or directly for human consumption (Durning, 1991; Durning and Brough, 1991);
- resource degradation and environmental damage caused by deforestation, overgrazing and pollution (Durning, 1991; Rifkin, 1992; Earthwatch, 1993);
- failure or marginal success of many large investments in livestock development projects to increase productivity and create impact on agriculture (Blackburn and de Haan, 1993).

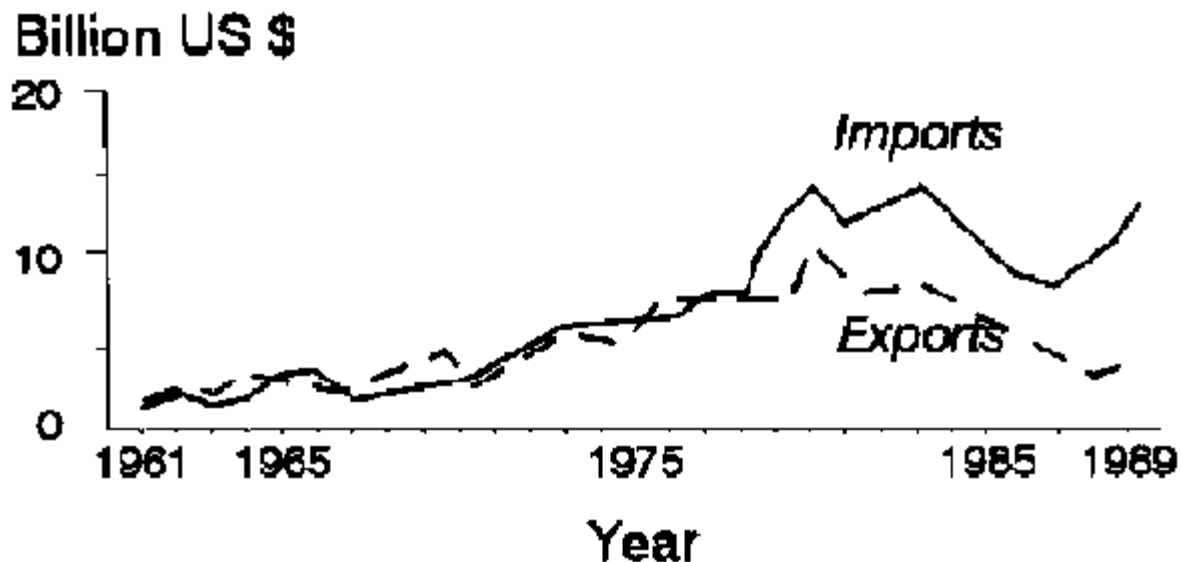
Grain as food or feed

Almost 50 per cent of world grain is fed to livestock yet 800 million people suffer from hunger and malnutrition (FAO, 1993a). This apparent paradox arises because 85 per cent of all fed grain is given to animals in developed countries whereas hungry people are mostly in developing countries because the poor cannot afford to buy cereals from the rich. Reduced use of grain as a feed in developed countries is sometimes suggested as a solution to the food security problem in developing countries. This approach can be used only to solve serious but temporary food insecurity such as a famine. Long term solutions lie in rationalizing production methods and appropriate costing and pricing.

Rapid expansion in poultry and pig output largely reflects worldwide changes in production practices from backyard, low input, scavenging systems to industrialized, high input intensive grain-based systems. Coarse grains and oil seeds have been regarded as the most convenient, if not the only, way to feed monogastrics and to fatten ruminants. Use of grain as feed has been assisted by production subsidies. Not including the costs of soil erosion, loss of soil fertility and environmental degradation have kept apparent production costs and prices low. If the ecological costs of grain production and intensive livestock management were fully charged to the livestock enterprise, costs of meat and milk would be so high that management practices would have to return to lower cost, lower intensity systems (Fitzhugh, 1993). Food security in the developing countries may be assured if production systems everywhere operate under a truly competitive environment.

Net grain imports into developing countries have steadily increased (Figure 3), however, particularly to feed animals that are eaten by the minority higher income sectors of society. Exports of animal feeds are not negligible, a large proportion of these being oilseed cakes which are important sources of by-pass protein and which could, in most cases, be better used locally to improve production from the national herd. This, in turn, would reduce imports of animal products. Grains are not indispensable for feeding stock and FAO has given high priority over the last 20 years to developing alternative feed systems, with little or no use of grains, for both monogastrics and ruminants. A Chinese project turned the cropping zones, over five years, into the major producers of beef using untreated straw and cottonseed cake as supplements, with no use of grain (Mack, 1993). Sugar cane juice, palm oil, sugar palm juice and cassava roots have been successfully tested to replace grains in pig rations in about 15 countries in tropical America and Asia. Other local energy sources are being actively sought as alternatives to grain.

Figure 3 Value of feed grain imports and exports in developing countries, 1961-1989



Environmental degradation

In recent years, there has been a growing volume of criticism against livestock from environmentalists. Prominent among these criticisms are that livestock contribute to:

- increased desertification through long term over grazing particularly of semiarid rangelands;
- deforestation by lopping branches for use as fodder and felling trees to make way for pastures as in Latin America
- the greenhouse effect, since they produce methane as an end product of rumen digestion; and
- water and environmental pollution through animal wastes.

Some of these criticisms are unfortunately levelled without hard evidence but hard evidence is emerging to show that livestock are not the environmental villains they have been made out to be. An extensive literature review on the impact of livestock on rangelands (Dodd, 1991) concluded that the effects of grazing and drought have been confused and that there was no solid evidence of irreversible effects on vegetation from livestock other than around water points and permanent settlements. Long term research in the Sahel in Mali clearly shows the resilience of Sahel rangelands and that annual biomass yields closely track annual rainfall even after extended drought and heavy grazing pressure (ILCA, 1992; Fitzhugh, 1993).

Deforestation and expansion of ranching into Latin American forests is sometimes linked with supplying beef to the North American market and to profitability of production. In reality, neither the North American market nor profits as such are the main reason for expansion of ranching in Latin American forests (Belk *et al*, 1992). It is rather the policies of various governments to provide subsidized livestock credit, technical services, roads, favourable market prices and tenure policies that encouraged land speculation (Hecht, 1989; 1992; Durning and Brough, 1993; Kaimowitz, 1994; McCorkle, 1994). Expansion of shifting cultivation due to poverty and population growth is a principal cause of tropical deforestation in developing countries (Cleaver and Schreiber, 1992; Winrock, 1992).

Livestock's contribution to the greenhouse effect has been overemphasized and ruminant livestock contribute only about 2.5 per cent of the total greenhouse gases. Gas emissions from cars and industries are far greater and have been increasing at a much higher rate. The

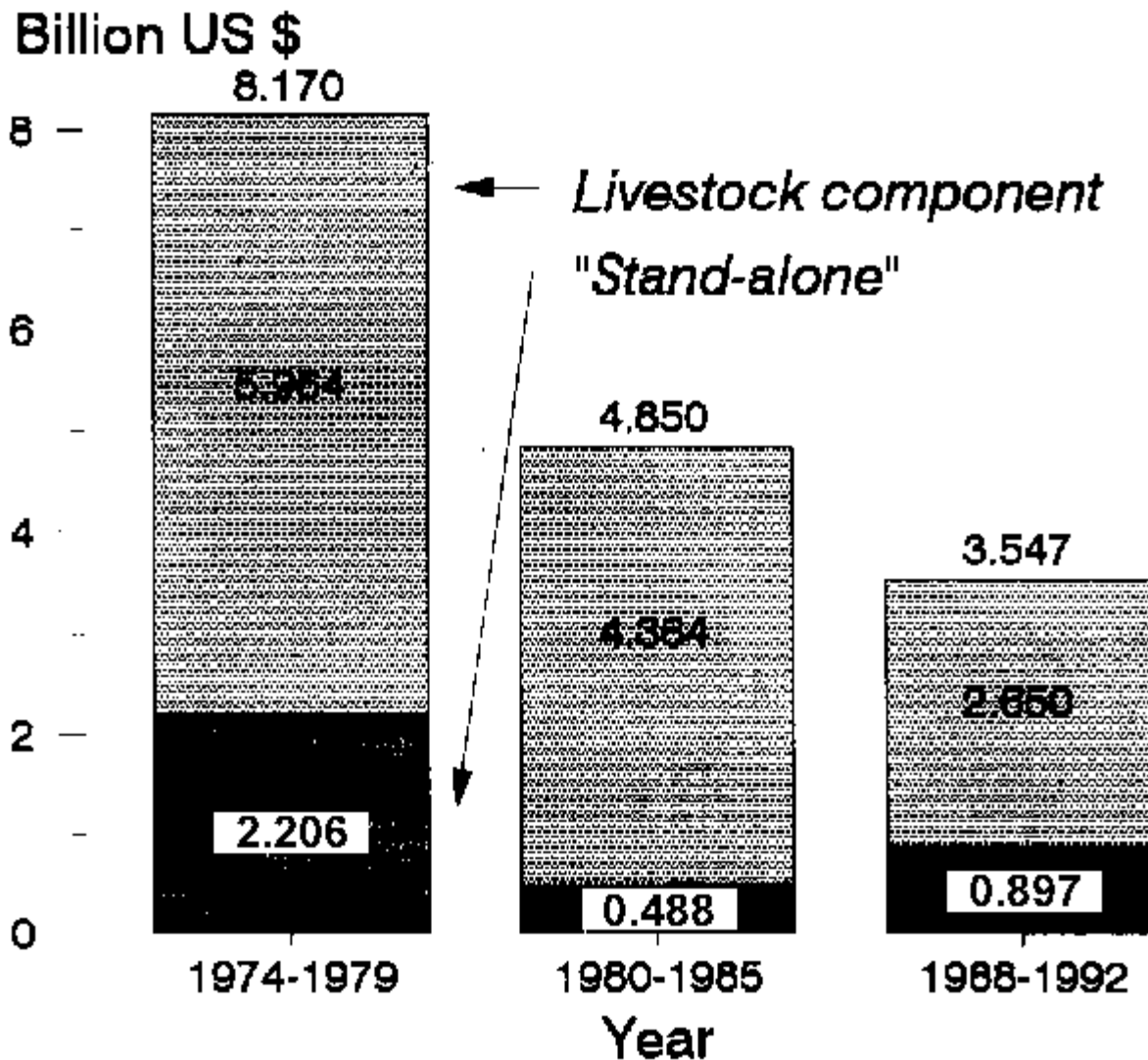
problem of pollution created through waste disposal is specific to intensive production systems in developed countries.

In general, improved livestock productivity, economic development and sustainable natural resource management are not incompatible goals. Appropriate technologies, policies and institutions will, however, be required to achieve that goal.

Successes and failures of livestock projects

Relative to its importance as a direct and indirect source of food and as a major component of sustainable development, the livestock sector is under-funded and under-resourced throughout the developing world. As an example within FAO, livestock is represented by a Division within the Agriculture Department and receives about half the budget of the fisheries sector which merits a full Department. CGIAR core budget allocation to livestock research is not congruent with the value of livestock products when the values of non-food products and services are included. In the World Bank, only four per cent of the loans given to the agriculture and rural development sector were for livestock projects although livestock are components in some integrated agricultural projects (Figure 4).

Figure 4 World Bank loans to livestock projects in 1974-1992



Bank funding for livestock declined (in constant 1991 dollars) from 1974 to 1992, especially for stand-alone livestock projects. This happened in spite of the fact that the success rate for livestock projects increased from 43 per cent during 1974-1983 to 64 per cent in 1988

whereas that for agricultural projects decreased from 75 to 55 per cent in the same period (Blackburn and de Haun, 1993).

Many livestock development projects have failed to meet their initial objectives but there are many successful projects. Some examples are:

- Operation Flood in India which promoted dairy development among small or landless farmers and created a modern and efficient dairy industry;
- a similar dairy project in Uganda which, under difficult conditions, successfully developed milk production near Kampala;
- micro cheese making units in Niger that provided jobs and income to several hundred women;
- a beef fattening project in China which used local cereal straw treated with urea and supplemented with cottonseed cake turned the farmers of two provinces, in a span of a few years, into the most important beef producers in China;
- on-farm testing and field support activities for a successful beef fattening project in northern Tunisia in the 1970s;
- the New World Screwworm project in North Africa that, using environmentally safe biotechnology, eradicated this pest in less than four years and is an example of efficient organization and cooperation between donors and UN agencies.

Projects have failed most frequently in their initial objectives because inappropriate technologies or institutions were used or because they were implemented in an unfavourable policy environment. The Asian Development Bank noted that the principal cause of poor performance and even failure in publicly and donor-funded livestock programmes and projects was the use of inappropriate technology.

A particular mistake was the import of high producing breeds that were unable to adjust to local conditions, notably feeding and diseases (ADB, 1993).

In West Africa, modern dairy plants were set up in several countries with donor funding to process locally-produced milk for urban consumers. The policy of dumping dairy products by advanced countries combined with inappropriate domestic trade and monetary policies subsequently made import cheaper than local production and collection. The dairy processing plants remained severely under-used or totally so and the development of the domestic dairy sector remains an unfulfilled goal.

Trends and projections in food production

During the last 20 years, output of livestock products has increased at similar and, in a number of cases, at higher rates than major cereals (Table 7). Major increases have been in monogastric meat production. Egg production also increased from 4.6 million tonnes in 1969/1971 to 15.3 million tonnes in 1988/1990, or by 331 per cent. It is projected that during the next 20 years, rates of milk and meat production will surpass those of the major cereals and that the increases in production from monogastric animals will continue to be considerably higher than from ruminants, provided feed is economically available for production.

By 2010, animal products are expected to contribute proportionally more to food supply and food security in the developing countries than they do at present.

Table 7 Trends and projections in livestock products, wheat and rice (million metric

tonnes) in developing countries

Item	Period			Growth rate (%)	
	1969/1971	1988/1990	2010	1970-1990	1990-2010
Milk	78.0	147.3	247.6	3.5	2.5
Meat	28.5	64.8	143.0	4.6	3.8
Large ruminants	12.1	18.6	32.3	2.2	2.7
Small ruminants	3.0	4.9	9.5	2.8	3.1
Pigs	9.7	28.3	64.0	6.1	4.1
Poultry	3.7	12.9	36.9	7.0	5.1
Wheat	67	132	205	3.8	2.1
Rice	177	303	459	3.0	2.0

Source: FAO, 1993b

Conclusions

The contribution of animals to both agricultural and overall economic development has not been adequately evaluated. Official statistics generally underestimate livestock contributions since many important non-food outputs which are difficult to quantify in monetary terms are excluded from calculations. The role of animals in development programmes is generally underrated, in spite of the increasing demand, especially in the developing countries, for animal products and services. Allegations about livestock's role in resource and environmental degradation are generally not fully documented.

Improved efficiency of animal agriculture with its various commodities and service products is critical to achieving sustainable agricultural development and food security, particularly in low income food deficit countries.

A prerequisite for sustainable development of animal agriculture is the development, testing under local conditions, and promotion of appropriate technologies that use local and affordable resources. Policies, infrastructure and support services must be established to enable such technologies to succeed and reach small scale farmers.

Integrating livestock and agriculture increases short term benefits to and long term sustainability of agriculture.

The multipurpose and flexible livestock sector is able to react to changes in national economies. Monogastric species and ruminants are adapted to varying local conditions and use local resources to produce products and services.

Increased ruminant productivity requires research to develop feeds and feeding systems, identify and use adapted genotypes, reduce mortality, improve production systems and inform appropriate policies.

Pigs and poultry are likely to remain the main source of meat where rapid urbanization is occurring. Use should be made of transferable technologies to expand small scale production. Emphasis should be given to feeds that do not compete with human food.

Facilities and credit for small scale producers should be emphasized, rather than major investments in institutions and facilities (such as big abattoirs, dairy plants and feedmills) which are usually oversized, overstaffed and overequipped.

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Development support and livestock

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¹ This is an expanded and updated version of de Haan (1992): Livestock Services for Small holders, Yogyakarta, 1992. Views expressed are those of the author and do not necessarily reflect the policies of the World Bank or its affiliates

Introduction

Livestock ownership is frequently equated with wealth but livestock development often benefits the poor. In Morocco and Egypt small farms have four to six times more animals per hectare than larger farms (Glenn, 1987). Landless farmers in India and those with less than one hectare own more than 30 per cent of cattle and buffaloes and have four times more stock per hectare than larger farmers. Higher stocking rates may not result in optimal efficiency but they demonstrate the importance of livestock development for rural growth and poverty reduction. Effective and sustainable livestock services are a key issue in rural development policy and they have attracted 30-50 per cent of international support for livestock development in the last 10 years.

This overview is a developer's perspective of the current state of key issues in the establishment and functioning of effective livestock services for small holders in low income countries. The paper covers issues and trends affecting all services. It uses examples from publicly funded development support for key services such as animal health, livestock extension, breeding, credit and marketing services.

Past trends and performance

India's Operation Flood developed a comprehensive service package which eventually reached about eight million farmers (NDDB, 1994). The Turkish Foundation created a viable integrated service and processing chain based on small poultry farmers (Unger, 1993). These two projects are among few exceptions to the general situation in which livestock services in developing countries have not been very effective, especially in reaching the poor. The two key factors leading to this situation were declining budgets and administrative efficiency, and changing clients, problems and issues. The long term lack of impact has resulted in a search for alternative systems.

Declining budgets and administrative efficiency

Fiscal constraints and poor management of resources caused livestock service staff numbers in many African and Asian countries to grow faster than the means (vehicles and fuel, pharmaceuticals, etc) to support them. This decline in recurrent non-salary funding forced the

services to cut back on field activities. In 1961-1962, for example, 33 per cent of livestock service budgets of six Sahel countries was allocated to operating expenditures. This share had been reduced to 25 per cent by 1975 and 16 per cent by 1988 (de Haan and Bekure, 1991). The situation in other regions is less serious but almost all livestock services in the developing world have seen large decreases in non-salary recurrent funding.

Changing clients, problems and issues

Increased demand for animal products and decreased grazing resources have led to intensification of production. Small holders with crossbred dairy cattle and pigs and hybrid poultry need higher quality services more focused on individual animal care. The introduction of crossbred dairy cattle in India, for example, increased the need for individual and immediate animal health care and for which the public sector was badly equipped. A similar shift is happening under the Chinese "lean pig" policy which involves an ambitious crossbreeding programme that will lead to a pig population that requires (and justifies) much more individual care.

This shift in technology coincided with a change in the profile of the livestock farmer as traditional livestock keeping evolves to more commercial operations. Cattle ownership in many African areas, for example, is shifting from ethnic groups with considerable indigenous knowledge to much less experienced crop farmers. These "new" livestock farmers demand more frequent and more sophisticated services than the archetypal public sector services cannot provide. In addition, there is decreasing emphasis on greater production and more regard for increased efficiency. Attention to the sustainable use of renewable resources is assuming importance and this also requires a different set of policies, services and supplies.

Current trends

The two most important trends in the institutional organization of livestock services now in the mainstream of the current development dialogue are a better distribution between the public and private sector and greater decentralization and transfer of responsibility to the beneficiaries.

Redistribution of public and private sector roles

Several publications of the last 10 years have discussed the distribution of responsibilities between the public and private sector, including the livestock sector (Umali *et al*, 1992). They recommend redistribution of responsibilities over three broad categories whereby the public sector has tasks, which it:

- needs to do itself;
- can subcontract to the private sector, but needs to supervise closely and (at least partially) finance; and
- can transfer fully to the private sector, with Government maintaining only an overview function.

Pure public sector responsibilities

These are pure public good services such as policy planning, quarantine, food inspection and quality control. This area has traditionally received considerable donor support and no significant innovative institutional structures have emerged.

Public service responsibilities which can be subcontracted to the private sector

These remain under the responsibility and supervision of the public sector and frequently have its financial support. They are goods with externalities, such as compulsory vaccinations,

extension through the mass media and research that is not patentable. In this area a significant number of new developments has emerged in recent years in the developing world.

Animal health

Subcontracting of compulsory vaccination campaigns to private veterinarians under (often partial) payment by the public sector has proven to be a very effective catalyst in developing private animal health care systems. This is clearly demonstrated in Morocco where the number of private veterinarians rose from two in 1983 to 130 by mid-1994 (World Bank data). This was due to an attractive subcontracting policy and strict curtailment of government involvement in private good services when a private veterinarian establishes a practice. It resulted in net savings for Government as the fee per animal vaccinated paid to the private operator was estimated to be lower than the average vaccination cost by the public veterinary service. Finally, it improved livestock protection as the private veterinarians, with stronger incentives, vaccinated on average a higher percentage than public sector staff (World Bank data).

Similar successful experiences also emerge from sub-Saharan Africa, where rinderpest vaccination is now being subcontracted to private veterinarians. Subcontracting also offers opportunities to increase the flexibility and impact of extension services.

Extension

Subcontracts with NGOs and private firms for extension are being introduced in, for example, Chile. A phased system has been introduced going from Government financed individual contacts, to group extension and finally to complete take-over by the beneficiaries (Amour, 1994).

Some interesting new incentive systems have also emerged recently where extension stays within the public sector. These include: (i) "contract extension", where village extension workers enter into contracts with farmers, or farmers' associations, based on a fee plus a share in the profits; (ii) "share cropping" with farmers for a profit. In this case, the farmers provide land, animals and labour, and the extension agent, with his easier access to credit, supplies the inputs. The share-cropped cow is the demonstration plot, where other farmers can see the effects of the new technology; and (iii) "voucher" programmes, whereby farmer groups are given Government vouchers that they can trade for individual or group extension to be delivered by individual extension agents (Ameur 1994).

Research

Competitive grant systems with possibilities for subcontracts to NGOs and private groups (and other Government organizations, such as universities) are being introduced in projects being funded by the World Bank in Indonesia and Kenya. Initial experiences are good.

Private sector responsibilities

These are pure private goods, such as clinical animal health care, animal breeding and credit.

Animal health

Considerable progress has been made in sub-Saharan Africa (especially in the Francophone part, where there are now an estimated 400 private vets, covering most of the clinical care and drug sales), North Africa, Eastern Europe and Latin America and the Caribbean. The public sector still dominates veterinary services in Asia, including West Asia. The discussion has now shifted in many countries from the role of the public and private sectors to distribution of responsibilities within the private sector. The role of auxiliaries (nonprofessional technical

assistants) is still very much a point of discussion (VSF, 1995)

Artificial insemination

This is still almost exclusively in the public domain in developing countries and subject to rigid rules of public administration (Walshe *et al*, 1991). The use of sophisticated equipment and inputs (including liquid nitrogen) since the 1970s and 1980s has led, in Africa and many parts of Asia, to AI services being too expensive, not available or so unreliable that farmers cannot use them. Almost without exception, conception rates to AI in developing countries are below 50 per cent (Mergos and Slade, 1987; Walshe *et al*, 1991) thus defaulting on the main objective of most farmers in the developing world of having their cows give one calf per year. Commercialization of the services, with more performance-oriented incentive schemes, is being introduced in North Africa and China. Pure private AI using fresh semen and adapted transport is also strongly emerging in China.

Credit

Thinking has changed considerably recently. First, credit appears less crucial in technology adoption than previously thought. Most farmers have access to informal sources and many agricultural and livestock technologies can be introduced gradually. Second, perceptions regarding private loan intermediaries, who used to be considered exploitive, is changing. Some exploitation by private loan intermediaries does exist but private (informal) credit institutions are less exploitive than originally thought (Yaron, 1992a, 1992b). In spite, however, of the importance of livestock to the rural poor and the need for initial capital to start livestock production, credit programmes have been largely unsuccessful in getting this target group involved in livestock production. The mobile nature of livestock complicates collateral requirements and the long production cycle makes livestock production less attractive to commercial bank loans. Group lending and other institutional channels have only recently been tested for livestock and experiences such as the Grameen Bank in Bangladesh are promising.

Impact of increased privatization

The impact of increased privatization and commercialization on the poor has not been fully documented. There is, however, increasing evidence that if a good or service is subsidized or provided free its access will be restricted to the wealthy and it will not be available to the poor. Subsidized interest rates in Latin America (but also elsewhere) mainly touched the wealthier minority of producers as political influence rather than market efficiency was the deciding factor in allocation of loan funds. It has been clearly shown (Leonard, 1985) that, when the Government of Kenya shifted to a greater degree of cost recovery, access of poor farmers increased significantly.

Participation and decentralization

Participatory development is an iterative process between different stakeholders in deciding their own development interventions (Chambers, 1993; World Bank, 1995). It is now frequently used as a means of improving the beneficiaries "ownership" in development projects. A considerable number of tools exists to improve the planning, based on Rapid Rural Appraisal techniques.

A project in Egypt (World Bank, 1995) formed a local task force to involve all stakeholders in a resource management project. The use of available tools (including semi-structured interviews, herders' perceptions on the environment, seasonal and historical calendars and older techniques such as cow histories) certainly improved the "ownership" of project interventions by local Bedouin. Key issues still concern the potential conflict between participatory development, which requires continual adjustment of objectives as feed back

from project beneficiaries becomes available, and sometimes rigid donor administration which, although less severe than in the past, still exists. A key outstanding issue will be the identification of credible process indicators to replace the physical input indicators of traditional project implementation.

Pastoral organizations

Pastoral organizations are one of two key Organizational forms in the livestock sector. They are important in range livestock projects in sub-Saharan Africa and are emerging in the West Asia-North Africa region. World Bank activities have been rather successful in mobilizing producers around the preferred inputs of animal health and water development in Senegal, Central African Republic, Mauritania and Guinea. They have been less successful in mobilizing support for resource management and many associations have not yet proved to be sustainable after project completion.

Processing and marketing organizations

This is the second key organizational form. Livestock products are perishable and do not give producers a great deal of leverage vis-a-vis their processors. This makes cooperative movements especially relevant in the livestock sector. Some important cooperative movements in the agricultural sector in the developing world are thus found in the livestock product processing industry, as shown by Indian dairy cooperatives and the Turkish Foundation. Both have successfully mobilized large groups of small producers and- have provided them with inputs and services and outlets for products. Monopolistic tendencies have emerged recently, however, in several successful coop movements. Inefficient processors could now become a factor in depressing producer prices and inflating consumer prices and thus constrain overall dairy development. A main challenge in the future, therefore, will be to prepare cooperatives for a more competitive environment.

Future directions in smallholder livestock development

Livestock development in low income countries needs to operate within the overall development objectives of reducing rural poverty, promoting rural growth and enhancing sustainable resource use. Future development support within the World Bank, for example, could therefore be expected to concentrate on three main areas.

Further fine-tuning of economic policies

Particular attention will be paid here to:

- creating "level playing fields" for all service providers;
- improving production efficiency; and
- environmental linkages to reduce the negative and enhance the positive impacts of livestock on the environment.

Strengthening services to small holders

This will be achieved by:

- continuing the development of private services in animal health and breeding; and
- focusing on public sector tasks such as livestock research and extension but not necessarily through public sector delivery.

In extension, alternative organizational forms, such as the involvement of NGOs and the introduction of performance related incentive systems would need to be explored. Publicly

funded research would need to concentrate on:

- technologies for small holders which would be low cost and "user friendly", to allow their use by non-professional staff and groups; and
- increase the efficiency and sustainability of renewable resource use.

Increased emphasis on environmental investments in the livestock sector

These, because of their significant externalities will become increasingly important in development support. Subjects for emphasis might cover the whole spectrum from land degradation and management (especially in the arid zones), through programmes to reduce livestock methane emission and then to cleaning of the environment.

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Impact of human activities and livestock on the African environment: an attempt to partition the pressure

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Introduction

The impact of human endeavours to eke out a living through crop and animal agriculture is examined in a holistic context in this paper. It is argued that the direct and indirect impact of livestock production on the natural resource base can only be assessed as an integral part of the overall pressures that human activities exert on the environment.

Removal of plant cover by livestock is usually identified as the major cause of impact. The analyses therefore focus on the main sources of pressure which continue to modify the vegetation cover of rural Africa. These sources include effects of fires and burning of biomass, fuel wood extraction and deforestation and land clearing.

Land degradation

Assessment of land degradation is usually confined to the drylands of the world, as other degrading human activities such as deforestation and biomass burning are assessed separately. Degradation is regularly reported for rangelands, soils and crop lands (Table 1). The severity of degradation for each is grouped into four classes, ascending from none/slight to very severe. In general, these classes refer to the percentage loss of expected productivity with moderate being less than 25 per cent, severe in the range 25-50 per cent and very severe more than 50 per cent.

Table 1 Degradation rates in African drylands

Total area (million km ²)	Amount of degradation					
	None/slight		Moderate		Severe	
	km ²	%	km ²	%	km ²	%
Rangeland						
13.42 ^a)	3.48	15	2.68	12	7.25	31
Soil						
12.9						

Arid	-	66	-	30	-	4
Semiarid	-	78	-	14	-	8
Subhumid	-	87	-	9	-	4
Rainfed crop land ^{b)}						
0.8	0.31	39	0.43	54	0.05	7

Notes:

a) Excludes hyperarid desert

b) Rainfed crop land is 55 per cent of all tropical African crop land

Source: Dregne *et al*, 1991

Rangeland degradation

Rangeland degradation is mainly related to the state of the vegetation cover of the woody and herbaceous strata. In Africa, rangelands are estimated to cover about 13.4 million km² or 60 per cent of the continent. This is close to the combined extent of the arid and semiarid zones and the drier parts of the subhumid zone (Dregne *et al*, 1991). Reductions in perennial grasses and woody biomass appear to be the main criteria to assess class values but the "yardstick to measure the potential" has not been clearly stated.

There is little doubt that woody cover in African drylands has decreased at a rapid rate in particular in the arid zone and in the drier parts of the semiarid zone. Needs for fuel wood and crop land has unavoidable impact on woody cover but how changes in herbaceous cover cause degradation is less clear. In the drier part of West Africa (< 800 mm annual rainfall) grasses are mostly annuals except on sites benefiting from run-on soil moisture. Their productivity is almost entirely determined by rainfall (Box 1). Perennial grasses dominate in East Africa at lower rainfall (up to 400 mm) because it is bimodal but in dry years the proportion of ephemeral annuals increases (Njoka, 1984; Herlocker *et al*, 1993).

Box 1

The resilience of Sahel Rangeland grasses

Annual grasses that dominate the various land units in the Sahel have an outstanding ability to produce large stocks of seed under many constraining circumstances

Traits that contribute to reseeding ability include:

- seed dormancy is restricted and is broken before the next growing season;
- date of flowering is governed by day length and therefore the period of seed setting is short and fixed;
- growth cycles adapt to the rainfall distribution pattern allowing at least some seed production even when rains are poorly distributed;
- plants develop protective devices against grazing when flowering and setting seed and possess efficient seed dispersal mechanisms;
- most species produce large numbers of tillers, depending on plant density and available soil moisture and nutrients;
- defoliation by livestock tends to increase tiller numbers although few tillers may reach the flowering stage; and
- under extreme continuous grazing pressure shorter cycle and lower yielding annuals replace longer cycle species and although these are palatable they are very resistant to grazing due to their short growing period.

As the herbaceous stratum provides most of the livestock feed, secondary productivity rises and falls with rainfall but is mostly controlled by heavy drought induced mortality. If the rangelands dominated by annual grasses are considered resilient rather than degraded, about 8-9 million km² move up into the none/slight class of degradation (Table 1).

Soil and crop land degradation

Soil degradation is less serious on crop than on rangelands, with 75 per cent of the drylands being unaffected (Table 1). Soil erosion, shifting sand and surface crust formation impeding infiltration and promoting run-off are among the major causes of degradation in upland soils. The same causes play a role in the degradation of rainfed crop land. It is probable, however that depletion of soil organic matter and nutrients is the most common cause of degradation (Smaling 1992). There is no substantial evidence that the major causes of soil degradation in drylands are grazing (34.5 per cent), deforestation (29.5 per cent) and agriculture (28.1 per cent) as asserted in a recent UNEP publication (Greijn, 1994).

Livestock distribution and stocking rates

It may seem odd to revert to livestock distribution patterns based on livestock statistics compiled during the late 1970s (Jahnke, 1982). Unfortunately, that analysis is the only available baseline linking livestock distributions to ecological zones within countries. Numbers have recently been updated but the older distribution patterns between zones and regions were maintained (Winrock, 1992).

About 76 per cent of the 154 million Tropical Livestock Units (TLU) in 1986-1988 were in lowland tropical Africa with 40 per cent of these being in the arid, 34 per cent in the semiarid and 26 per cent in the subhumid zones (Table 2). The other 24 per cent were mainly in the highlands (18 per cent) and the humid zone (6 per cent). East and West Africa accounted for 56 and 26 per cent of the total livestock wealth whilst Southern (12 per cent) and Central Africa (6 per cent) had fewer numbers (Winrock, 1992).

Ratios between people and livestock are indicative of their importance in rural production systems. The highest ratios are found in pastoral East Africa. More sedentary systems average 0.5 TLU/person (Table 2) except in the subhumid and humid zones where livestock wealth is very low (Table 3) and where the proportion of small ruminants is high.

Table 2 Densities of rural people and livestock in the arid, semiarid and subhumid ecological zones and corresponding geographical regions

Zone	Region	Number/km ²		TLU/caput	Percentage of	
		TLU	People		TLU	People
Arid	West	6.3	4.1	1.56	11	5
	East	11.9	6.1	1.93	24	9
	South	7.4	4.2	1.76	4	1
	mean/total	9.1	5.1	1.78	39	15
Semiarid	West	11.1	24.0	0.46	17	25
	East	13.1	21.2	0.62	14	15
	South	3.1	7.1	0.44	4	6
	mean/total	9.0	17.7	0.51	35	46
	West	6.1	22.3	0.27	7	19

Subhumid	East	16.3	14.5	1.12	15	9
	South	2.0	6.8	0.30	3	8
	Central	0.5	6.3	0.08	1	3
	mean/total	5.8	12.4	0.46	26	39

Source: adapted from Jahnke, 1992

Table 3 Density of rural people and livestock in the eastern highlands and in the humid zone

Item	Ecological zone and region			
	Highlands		Humid	
	East/Central ^{a)}	Ethiopia	West ^{b)}	Central ^{c)}
People/km ²	149.2	36.6	49.2	7.1
TLU/km ²	58.3	27.5	6.1	0.4
TLU/caput	0.39	0.75	0.12	0.06

Notes:

a) Kenya, Uganda, Burundi, Rwanda

b) Nigeria, Ghana, Guinea, Sierra Leone

c) Zaïre, Gabon, CAR, Congo, Cameroon

Source: adapted from Jahnke, 1992

In the Ethiopian highlands, population and livestock pressures are high (up to 120 people and 130 TLU/km²) due to a near universal reliance on cattle and equines for soil tillage and transport. Intensive small holder dairying has transformed the livestock industry in the Kenya highlands where highly productive pastures, cut and carry forage production and supplementary concentrate feeding allow stocking rates as high as 100 TLU/km². Extremely high population pressure in the highlands of Rwanda and Burundi explain why stocking rates are lower (50 TLU/km²) due to continuous conversion of pastures to cropped land. Feed resources are thus scarce here. They include banana stems and leaves, spent grain from beer brewing and forages grown on erosion bunds.

From 1979 to 1988, cattle increased by 18 million (12 per cent), small ruminants by 48 million (22 per cent) and camels by two million (18 per cent). Increases in numbers have not been uniform across zones and regions. In the arid zone, due to droughts in the early 1980s, cattle numbers stagnated or declined due to high mortality and permanent migration into better rainfall areas. This, combined with rapid expansion of ox traction cropping of cotton, boosted cattle populations in subhumid West Africa.

Biomass removal

Livestock

Consumption of plant cover by livestock has a major impact and overgrazing is believed to contribute substantially to desertification and land degradation (Dregne *et al*, 1991). Plant removal reduces protective plant cover, vigour and regrowth capacity, the effects of which increase exponentially with removal rates (Belsky, 1988; Hiernaux *et al*, 1994). Indirect effects include trampling which leads to soil compaction and, when excessive (as along cattle trails and around homesteads and water points), may cause run-off and gully erosion. Grazing

implies removal of nutrients (NPK and trace elements) and organic matter, part of which is returned as faeces and urine. Depending on the recycling processes, a substantial portion is retained in the ecosystem (de Leeuw *et al*, 1994; Fernandez-Rivera *et al*, 1994).

To assess impact on a continental scale overall biomass removal can be derived from the expected intake of the entire population of grazing ruminants. The parameters included in this computation (Table 4) are based on meta-analyses of a large set of data (Fernandez-Rivera *et al*, 1994) on intake and faecal output providing gross and net removal rates, and the fraction of herbaceous forage and browse in the intake. Gross removal amounts to 460 million tonnes of dry matter (DM), over 80 per cent of which is from the herbaceous layer. Cattle account for 70 per cent of the total removal. Small ruminants and camels consume the remainder, including almost 90 per cent of the browse totalling 83 million tonnes of DM. Net consumption averages 55 per cent of gross intake so that over 200 million tonnes are potentially recycled back to the ecosystem.

Table 4 Gross and net annual feed intake of domestic ruminants in tropical Africa

Item	Livestock species			
	Cattle	Sheep	Goat	Camel
Number (million)	163	124	145	13
Average weight (kg)	175	25	20	250
Feed intake (t DM/year)	2.00	0.40	0.33	2.86
Faecal output (t DM/year)	0.90	0.18	0.14	1.23
Net removal (t DM/year)	1.10	0.22	0.19	1.63
Proportion browse in diet	0.05	0.20	0.50	0.90

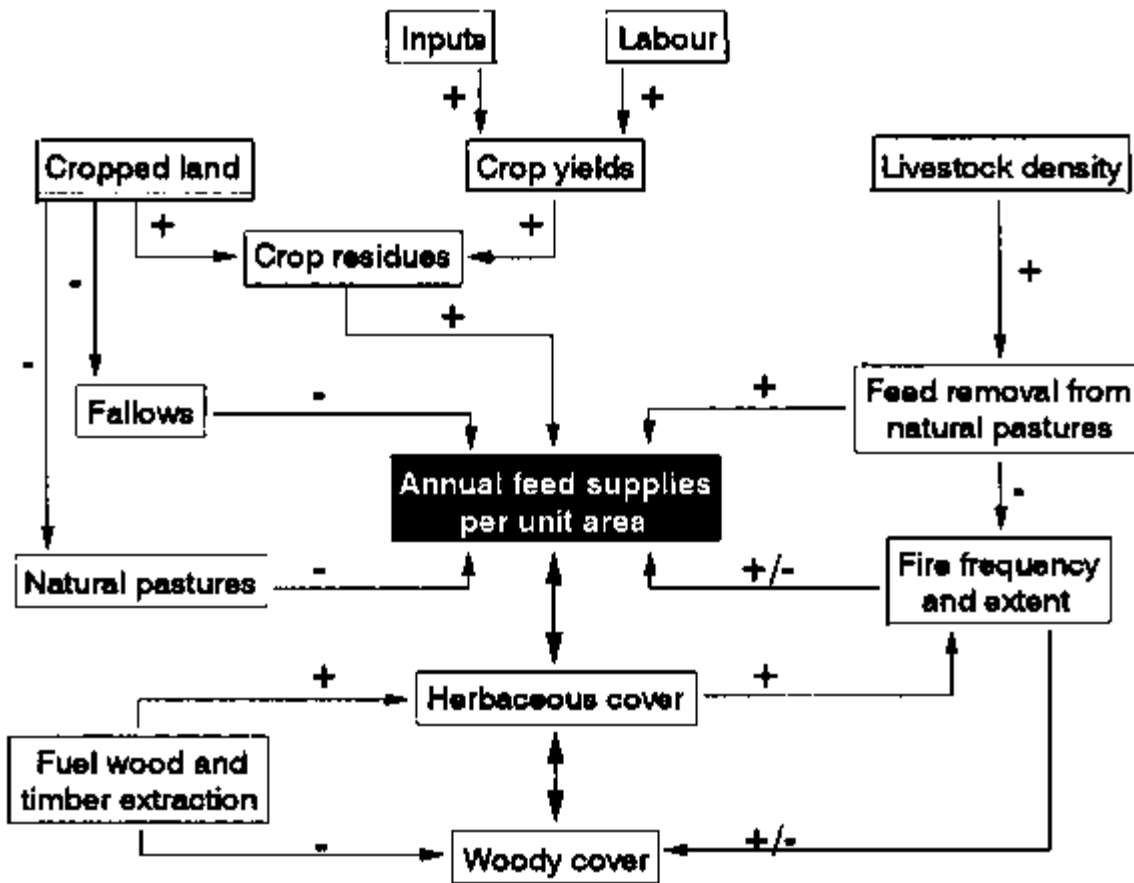
Source: adapted from Fernandez-Rivera *et al*, 1994 except livestock numbers which are from Winrock, 1992

Comparing these gross removal rates with actual stocking rates provides an index of impact per unit area of land. At 10 and 20 TLU/km² of stocking, roughly 0.3 and 0.6 tonnes DM of biomass are eaten. Hence, given average end of season yields of forage in the arid and semiarid zone of 0.5 and 1.5 tonnes DM/ha, the consumed fraction would be 60 per cent and 40 per cent in the two zones. These use rates may seem dangerously close to the recommended "proper use" factors of 0.3 to 0.5 (de Leeuw and Tothill, 1993). The presumed impact is much less, however, because 60-75 per cent is grazed during the dry season without impairing the subsequent regrowth potential of the grass cover. In the arid zone, impact on the herbaceous cover is further mitigated by browse consumption of camels and small ruminants. The relative proportion of perennial and annual species further modifies herbivore impact as annuals are generally the most resilient.

Highly aggregated feed demand: supply ratios ignore local factors limiting access such as flooding and cropping during the growing season, dense woodland and thickets often combined with tsetse infestation, steeply sloping terrain and areas without water. Use of grazing is also affected by site selection for pastoral settlement and by the livestock wealth of sedentary farmers. It is often believed that remote areas attract pastoralists but a strong correlation ($p < 0.001$) has been shown (Bourn and Wint, 1994) between livestock densities and the percentage of cultivated land and human habitation in West Africa and that "there is little room for doubt that livestock tend to congregate where land is cultivated". Settled farming communities attract herders and herds because they are close to water supplies, markets and other infrastructure. More importantly, livestock ownership by farmers increases with intensification of land use (Mortimore, 1989; de Leeuw *et al*, 1994).

Encroachment onto grazing land, including creation of national parks and game reserves and by squatter farmers, is usually listed high as a cause of increasing grazing pressure. It can be argued, however, that converting land from grazing to crops increases overall feed supplies, in particular in subhumid areas with high fire frequencies. Intensification reduces the fraction of grazable biomass removed by fires and raises output of crop residues (Figure 1). Fire hazards are lessened by greater herbage and woody biomass removal and a greater heterogeneity and patchiness of the vegetation.

Figure 1 Multiple effects of land use intensification on livestock feed supply per unit area



Burning

Fire in tropical Africa has received renewed attention since it was realized that biomass burning contributes 42 per cent of the gross atmospheric emissions of CO₂ (Cachier, 1992). Africa contributes 43 per cent of the total which exceeds the combined emissions of South America and Asia (39 per cent) (Williams and Balling, n.d.). The area of tropical forests is much greater (15 million km²) than that of humid savannas (9 million km²) but it is estimated that only 90000 km² of forest are burned every year compared to 5.4 million km² of savanna (Cachier, 1992). The total amount of burnt biomass in Africa is 2820 million tonnes DM to which savanna fires contribute 2500 million tonnes (Table 5).

Table 5 Estimated annual burnt biomass in tropical African savannas by zone

Item	Zone and subzone				Total/mean
	Semiarid		Subhumid		
	Dry	Wet	Dry	Wet	

Total area (million km ²)	2.75	3.41	3.04	0.89	10.10
Proportion burnt	0.3	0.4	0.7	0.7	0.5
Area burnt (million km ²)	0.82	1.36	2.12	0.62	4.92
Burnt biomass (m.t. DM ha/yr)	2.9	5.3	5.9	4.6	5.1
Trees and shrubs	1.4	2.3	3.4	2.9	2.7
Herbaceous layer	1.5	2.0	2.5	3.0	2.4
Burnt biomass (million m.t.)	238	721	1250	285	2494
Trees and shrubs	115	313	721	180	1329
Herbaceous layer	123	408	529	105	1165

Source: recalculated from Delmas *et al*, 1991

Savanna fires in tropical Africa extend roughly from 15° N to 25° S latitudes. The area potentially subject to fire hazard is of the order of 10 million km² encompassing savannas in the semiarid, the subhumid and the drier part of the humid zones (Table 5). Almost all savanna fires occur during the dry season, from December to March in the northern hemisphere with the peak in January. Night-time low-light satellite imagery shows the highest frequencies of fires in a broad belt between 3° N and 10° N, coinciding with the subhumid zone and secondary vegetation in the humid zone (Cahoon *et al*, 1992). Farther north, fires are more patchy and extend into southern Mali, Burkina Faso and Sudan.

South of the equator frequent fires reach peak occurrence in southern Zaïre in June and then sweep eastward to reach maximum values in Mozambique in September. Fires are widely spread over the entire dry season between 0° and 18° S in Congo, most of Angola, the southern third of Zaïre, most of Zambia and eastern Tanzania (Cahoon *et al*, 1992).

Interpretation of AVHRR/NOAA and LANDSAT imagery combined with field observations indicates that about half the fire prone zones are burned each year (Table 5). Annual fire frequency decreases from 0.7 to 0.4 with diminishing rainfall, mainly because of reduced fuel loads. Along the rainfall gradient, combustible biomass, comprising mainly standing grass and tree and shrub foliage, falls from 7.5 to 3.5 m.t. DM/ha. Because most fires are wind-driven, they pass through rapidly and thus the amount of woody biomass destroyed is negligible (Delmas *et al*, 1991).

Woody foliage and herbaceous biomass were partitioned by difference. As fire initiation needs a combustible ground mass greater than 1 m.t. DM/ha it seems likely that fires in the drier areas burn off about 1.5 m.t. DM/ha on average. With increasing rainfall, standing dry herbage and litter increase to median values of 3.0 m.t. DM/ha although in West Africa much higher herbage yields are recorded (Boudet, 1975; ILCA, 1979; Cesar, 1991).

These computed foliage yields are in agreement with literature sources (Walker, 1980) but may be overestimated where combustion rates are lower than the 80 per cent that has been adopted elsewhere (Delmas *et al*, 1991). This may partly explain some lower estimates (de Leeuw 1992) on a total area of 3.3 million km² with a biomass loss of 800 million tonnes DM, this being only about 30 per cent of the 2500 million tonnes shown in Table 5. The two estimates produced respective average burned mass amounts of 5.1 m.t. DM/ha and 2.7 m.t. DM/ha. The major conclusion arising from these analyses, however, is that fires remove about half the dry season herbaceous biomass or 1000 million tonnes DM per year, about 45 per cent of which is from the semiarid savanna. Assuming lower combustible fuel loads and reduced proportions of burnt land with rising rural population density a revised estimate of the contribution of the semiarid zone would be lower and amount to 32 per cent (de Leeuw 1992).

Fuel wood extraction

The impact of fuel wood use by local rural populations and the more distant urban centres on wood resources and vegetation structure is a major pressure on the environment. In rural Africa, 80-90 per cent of the energy demand is derived directly from woody vegetation and wood-derived charcoal is an important source for food preparation and heating in the urban sector.

Total demand in tropical Africa of the rural population of 350 million people in 1994 would convert to 170 million tonnes of wood at average annual use rates of 0.5 t/person. The urban population of 150 million would require 60 million tonnes at a use rate of 0.4 t/head. Other sources of organic fuel include crop residues and animal dung. In areas such as the Ethiopian highlands where wood is scarce these sources supply 45 per cent of total demand.

Given the high transport cost, fuel supplies in rural areas are mostly from nearby sources, either from a farmer's own land or communal areas. The impact of wood cutting is therefore localized and directly related to site-specific population densities. At a density of 20 people/km² - a common figure in many parts of the semiarid and subhumid zones - wood extraction would amount to 10 t/km²/annum. In these zones, standing woody biomass in farm and fallow shrub lands varies from 3-8 m.t. DM/ha but rises to 20 m.t. DM/ha in well developed *Acacia* woodlands (Franklin and Hiernaux, 1991).

Similar estimates of woody cover were made in an assessment of wood volume and vegetation cover over 320000 km² in northern Nigeria. Woody biomass in farmed and shrub lands was in the range 3-7 m.t. DM/ha whereas in woodland it was in the range 15-30 m.t. DM/ha. Fuel wood biomass of the entire area averaged 7.5 m.t. DM/ha (RIM, 1991). At annual increments of 0.2 m.t. DM/ha (Groten; 1991) fuel wood support capacity would be about 40 people/km². Standing woody biomass gradually diminishes in excess of this density unless wood from distant surplus areas is available. The most critical part of the survey area was the dry semiarid zone (< 700 mm rainfall) where rural population density was high (> 150 person/km²), cropped land exceeded 60 per cent and there was more pressure from livestock at densities of more than 50 TLU/km² (Mortimore, 1989, RIM, 1991; Bourn and Wint 1994).

Deforestation and land clearing

Discussion on deforestation in Africa usually emphasises the closed forests of the humid zone. Estimates combine exploitation for commercial timber, removal of woody cover related to slash and burn agriculture and conversion to small holder or plantation tree crop production. African closed forests covered 2.0 million km² in 1985, or half the area designated as the humid zone. Annual projected deforestation rates for 1981-1985 averaged 0.6 per cent or 12000 km² (World Resources, 1989). The rate for open woodlands was estimated at 0.5 per cent representing an annual area of 23400 km²

Statistics on clearing of new land and of old fallows are difficult to interpret as there is overlap with data on deforestation. In contrast to Latin America, clear felling of woody cover to open land for cropping is still rare in rural Africa. In most cases land clearing is a gradual process and useful trees are retained, this explaining the wide occurrence of parklands in tropical Africa (Nair, 1989; RIM, 1991).

About 1.5 million km² of land was classified as crop land in 1985-1987 (World Resources, 1989), representing 6.4 per cent of total land. If it is assumed, however, that lack of rainfall precludes cropping in areas with less than 350 mm in West Africa and less than 500 mm in East and Southern Africa (Ellis and Calvin, 1993), the cropped area would rise to 8.7 per cent and this would increase further if expressed as a ratio of the total of potentially arable areas if

land with shallow stony soils and very steep slopes were excluded.

Cropped areas expanded rapidly in 1965-1975 but possibly decelerated thereafter. In 1965-1985, 15 of 36 major countries in tropical Africa had growth rates exceeding 20 per cent, and 11 countries had rates of over 50 per cent. In contrast, 21 countries showed less than 5 per cent expansion in 1976-1986, whilst crop land areas contracted in several more. Expansion greater than 10 per cent continued into the 1980s in only six countries (World Resources, 1991). Total crop output seems to corroborate these trends with rapid growth during 1965-1973, a drastic slowing down in 1973-1980 and then an upturn in 1980-1987. To what extent these swings in output can be attributed to the effects of rainfall fluctuation on crop yield per unit area is not clear.

An increase of only five per cent expansion of crop land over 1976-1986 - equivalent to 7.3 million ha - seems incompatible with a rise in the rural population averaging 7.5 million/yr as this would indicate that each additional person adds less than 0.1 ha to the pool of cultivated land (Winrock 1992).

Biomass addition

It is usually accepted that savanna vegetation becomes more dense and reverts to woodland when protected, especially when fires are effectively excluded. A series of burning experiments was established during the 1950s across the savanna regions of English-speaking Africa (see bibliography by Wein and Edroma, 1986). The major purpose was to assess the use of fire as a rangeland management tool, mainly to promote the grass component and suppress woody regrowth, especially of vigorously coppicing species.

Woody regrowth in savanna systems is environmentally desirable to control erosion, supply fuel wood and sequester carbon but farmers dislike regrowth in their fields as it reduces the grazing potential for cattle. Bush encroachment thus reduces the feed supply: demand ratios if demand is not reduced through destocking. This positive feedback between overgrazing and invasion of woody species is described for the Borana region in Ethiopia (Coppock, 1993) and shows that woody growth reduces herbage yield and limits access by stock, thus exacerbating grazing pressure on land with less bush (Box 2). Overstocking on Zimbabwe ranches was linearly related to financial loss due to reduced beef output from bush infested grazing land, losses being less severe on ranches with browsing wild herbivores (Kreuter and Workman, 1994). Similar interactions between fire frequency and herbivory by grazers and browsers (especially elephants) were highlighted in models developed to predict long term trends in woody and herbaceous biomass and its effects on the productivity of land stocked with mixed domestic and wild herbivores (van Wijngaarden, 1986).

Box 2 Bush encroachment: the case of Sidamo in Ethiopia
Climate Semiarid to subhumid with 600 mm annual rainfall in two seasons: droughts occur one year in five and multiyear droughts one year in twenty
Cyclic herd performance drought losses ® recovery ® overgrazing (with 50 per cent drought loss and 6-8 year recovery cycle) resulting in grassland (perennial grasses) ® woodland (mainly <i>Acacia</i>) due to increased grazing pressure

repeated defoliation ® nutrient removal ® nutrient removal in topsoil ® reduced vigour ® less reseeding ® reduced or no fire
Effects
shift from herbaceous to semipermanent dense woody cover access to grazing stock reduced increasing pressure on remaining more open land leading to lower animal output lower income and impaired food security of cattle owners
Remedies
prescribed burning during recovery phase planned woody cover reduction through fuel wood and charcoal sales hay making and <i>Acacia</i> pod collection for supplementary feeding opportunistic crop production in favourable areas in good years greater livestock offtake when density dependent phase approaches

The complexity of these interactions is also shown by the potential effects of increasing population and livestock density on fire frequency and extent and the potential consequences for the overall feed supply at the community level (c.f. Figure 1).

Further additions to woody biomass arise from fallow regrowth after cropping. Recovery is particularly rapid where fire tolerant species that coppice vigorously from extensive root systems are dominant. The destruction of primary forests due to slash and burn agriculture in the humid zone is similarly countered by increases in secondary forest cover and conversion to tree crop agriculture. In Côte d'Ivoire between 1965 and 1985, for example, one third of the forests were converted to other land use. Some 28 per cent of the 6 million ha was converted to tree crops, seven per cent was used for food crops and 65 per cent reverted to secondary woody formations. Thus over 90 per cent of the land retained some form of woody cover (Spears 1986 quoted in Ehui and Hertel, 1989).

If, during the 1980s, the annual rate of land clearing was restricted to about 1 million ha, the removal of biomass would be very small in comparison to that removed by livestock, fire and by use for fuel wood. Herbaceous cover and woody foliage are usually burned after clearing whereas woody stems and trunks are removed for fuel or for building material.

Discussion and conclusions

Partitioning of annual biomass removal between the three major sources of impact shows that livestock grazing is responsible 24 per cent of the herbaceous biomass loss and for 14 per cent of the combined woody and herbaceous loss in a total of 3200 million tonnes DM (Table 6). These fractions would diminish substantially if only net ruminant intake were considered. Given the inverse relationship between the extent and frequency of fires and livestock density, it is postulated that greater livestock pressure reduces biomass removal by fires, thus increasing the available herbage and reducing the relative removal rates by livestock.

The impact of fuel wood removal depends on whether dead or live biomass is taken. Where fires are frequent and woody cover is adequate (as in most of the subhumid zone) cutting of live vegetation is rare and loss to the ecosystem is therefore minimal. Charcoal production which accounts for a quarter of the total has greater impact as valuable hardwood species, including *Acacia*, are selected and overall savanna biodiversity is reduced.

The partitioning of biomass removal throws light on the relative importance of the pressures exerted by human activities. It has, however, been argued that these impacts should be aggregated (de Leeuw, 1992) rather than partitioned as is done by UNEP (Greijn, 1994). By assessing support capacities for crops, livestock and fuel wood an aggregate index could thus emerge that would measure overall impact on the environment. Depending on ecosystem

resilience -emanating from climate, landscape and characteristics of the soil and vegetation cover - risks of degrading processes and their resulting impact could then be identified. Rather than partitioning sources of impact, causes of degradation such as wind and water erosion and nutrient depletion in soils due to crop and biomass removal could be given importance rankings and then aggregated.

Impact assessment could easily be incorporated into the procedures that have been developed by FAO to estimate the human support capacity from assessment of potential yields and outputs of crops (Higgins *et al*, 1987). Actual crop yields are derived from the suitability of land by assessing climatic and edaphic attributes at given levels of inputs. Conversion of yields of appropriate crop mixes into quantities of calories and protein enables the computation of potential population densities that the food output can support. Comparison with present and future anticipated population densities allows the calculation of critical areas where food output is or will become insufficient to meet minimum human requirements.

Livestock and fuel wood productivity models have recently been added by FAO to the estimation of potential productivity of land resources (Kassam *et al*, 1991). These models are designed to operate on a digitalized land resource data base and include provisions for quantifying soil erosion hazards and resulting estimates of "tolerable" soil losses. Since the three models are interphased with each other, land productivity can be optimized for any given set of development constraints and demand. A contextual framework thus exists that incorporates the essential building blocks for assessing whether current land use is sustainable and could accommodate location specific data sets to estimate the impact on the environment.

Table 6 Annual gross removal of biomass by livestock fires and fuel wood extraction in tropical Africa (million tonnes DM)

Source of removal	Herbaceous stratum	Woody stratum		Total
		Foliage	Wood	
Livestock	378	83	-	461
Fire	1165	1320	-	2494
Fuel	-	-	230	230
Total	1543	1403	230	3185

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Discussion sessions: Part One

[Keynote paper: The contribution of livestock to food security and sustainable development](#)

[Development support and livestock services](#)

[Impact of human activities and livestock on the African environment: an attempt to partition the pressure](#)

Keynote paper: The contribution of livestock to food security and sustainable development

Discussion summary

This Keynote Paper incited discussion over a broad range of issues. Principal among these were the functions of livestock in mixed farming systems and their various roles in use of natural and other resources, the supply of and demand for livestock and livestock products, the development and transfer of technology to beneficiaries and policy issues.

Livestock functions and resource use

The functions of livestock and the need for using livestock for utilizing resources and for providing labour opportunities needs to be seen in relation to farm size, which is an indication of land availability, and labour availability. The relative importance of livestock in relation to other enterprises may change with farm size and other production factors. The implications to be drawn from this are important for assessing the importance of livestock for food production and for identifying research needs (Peters). It is true that issues of size, scale and structure as they relate to livestock in developing countries are not adequately known so they do need to be given adequate attention. These relationships do, however, vary across ecozones and regions. In South Asia, for example, landless people raise livestock by using feeds, which have no or very low opportunity cost, from roadsides and pathways and thus generate income and employment (Fitzhugh).

Attention needs to be given to the effects of livestock development on rain forest clearance and on wildlife species diversity (Young).

The role of manure in soil fertility should not be overemphasized because manure may not be enough to maintain fertility in some situations (Oram).

["Impact of human activities and livestock on the African environment: an attempt to partition the pressure" by de Leeuw and Reid (pp. 29-38) covers some of these issues in more detail]

Supply and demand for livestock products

The importance of income growth on demand for animal products given that such goods are essentially "superior goods" and that prices are now low needs to be studied. Caution is also needed in recommending expansion of livestock production to reduce import dependence without making reference to comparative advantage factors that might mitigate against

expansion of livestock production (DeRosa). Relations among price, income, supply and imports are complex and multilayered and will be better understood in a systems framework that considers both micro and macro levels. Income is a major determinant of demand and if supply increases in relation to demand prices remain low. Research and development aimed at increasing supply will benefit both consumers and producers although the former will benefit more than the latter as has happened in the developed countries (Fitzhugh).

Promoting small farm production while trying to keep prices low may be counterproductive. Domestic dairy production in developing countries will be adversely affected by GATT (Chantalakhana). It is true that the dairy sector in developing countries does not always suffer because of comparative disadvantage but because of dumping by developed countries. Appropriate policies are required to support suitable production environments (Fitzhugh).

Adverse impacts that arise when developed countries protect producers from competition are less production because world prices are lower and income is also lower so there is reduced demand. Developing countries control prices to urban consumers, however, which also results in less production that works against both urban and rural welfare. Processing controls that affect efficiency also suppress production. It is not yet known if production will increase in response to removal of controls after structural adjustment policies are completed. As these factors have been entrenched for a long time there is potential to improve livestock's contribution to development but this needs to be seen in a general equilibrium context of who gains, who loses and what are the impacts that will induce further changes (Young).

The only way prices can be lowered to the benefit of both producers and consumers is by cutting costs per unit productivity. ILRI attempts to do this by generating and spreading new technology to allow production increases at lower costs. Conflicts between producer and consumer interests with respect to price level changes will not be an issue if lower prices are technology driven (Badiane).

Low prices should not be a concern because livestock products are both price and income elastic. Demand may be high when prices are low so that total production and revenue will increase (Ehui).

["Macroeconomic, international trade and sectoral policies in livestock development" by Williams, DeRosa and Badiane (pp. 45-68) and "Research and technology transfer for livestock development" by Ehui and Shapiro (pp. 69-78) cover some of these issues in more detail]

Technology and policy

Project failures are due not only to technology and policy but also to human capacity. There is a need to understand why problems have arisen and the goals of people in specific regions or under varying conditions. The meeting should look at approaches to research and development in formulating strategies for low income countries (Ostergaard).

Dependency on imports can be reduced through technology improvement, particularly in cases of subsistence animal husbandry with largely under-commercialized livestock sectors. By removing policy and institutional constraints and providing improved technologies production can be raised efficiently to meet higher consumer demand as economies expand and levels or rates of growth of imports are reduced (Badiane).

Much can be done to serve producer and consumer interests simultaneously by an intelligent choice of production systems. Whether all tropical low income countries should aim to increase livestock production is questionable but there is an overall obligation to rationalize production systems in order to make the most efficient use of resources for the long term benefit of the whole community (Vaccaro).

["Research and technology transfer for livestock development" by Ehui and Shapiro (pp. 69-78) covers some of these issues in more detail]

Development support and livestock services

Discussion summary

The discussion on this paper again covered a broad range of questions. The relative roles of the public and private sectors were considered very important. There was general consensus that clear distinctions must be made between the role of the state in public good areas and that of the private sector in private good areas. Privatization should not be pushed too fast where a private sector was not yet able to perform efficiently in the interests of producers and consumers. The role and timing of credit were also considered important.

Private and public sectors

The private sector needs to be defined. Individuals form producer cooperatives in which the private element is the farmer. The status of the cooperative in this schema needs clarification (Peters). Private initiatives to form associations are an important instrument for development and these are "private". This is not an area for public intervention but such associations may become partners with the public sector in development activities (de Haan).

Division of responsibility between private and public sectors is important for developing countries but moving too fast towards privatization of essential services may not be to the advantage of small holders (Chantalakhana). It is true that moves toward the private sector should not be too fast but private/public task sharing needs to be promoted. Where the private sector has an advantage government policy should support private initiatives (de Haan).

In Eastern Europe, both private and public sectors are competing for research funds. Consideration should also be given to both public and private institutions in research in developing countries (Oram). Research contracts may be given to universities, NGOs and private institutions. In the developing countries universities and NGOs are targets for research funding but the "pure" private sector is still largely undeveloped (de Haan).

Giving entire responsibility to the private sector for genetic improvement is not advisable (Vaccaro). It is agreed that genetic aspects should not be given to the private sector (de Haan).

Poor infrastructure is a major problem in many developing countries and will not help privatization (Oram). Roads are important and will remain mostly a public sector activity. In some cases construction is related to development projects including dairying. Processing and collection of milk is mainly in the public sector but with improved roads these are better done by the private sector. The World Bank will emphasize this aspect of development (de Haan).

Credit

Credit for small holders is generally important. Timing may, however, be more important than credit *per se*. Pastoralists usually sell animals at difficult times when prices are low and allowing them credit at these times may save them from loss and increase their buffering capacity (Williams).

Small holders have a poor record of repayment of public funded credit. Group pressure may not be the best way to ensure repayment. Credit may not be as critical for technology adoption as was originally thought. Collateral for credit does remain a problem but group responsibility

has been shown to be a workable alternative for poor households (de Haan).

Credit may be given to input supply agencies and intermediate marketing agents who will ensure supply of inputs and purchase of products: both of these are essential for increased production (Shapiro). Input supplies and market agents need short term credit while farmers often need medium to long term credits. Both needs are important and one cannot be fully substituted for the other (de Haan).

Impact of human activities and livestock on the African environment: an attempt to partition the pressure

Discussion summary

There was general consensus during discussion that the role of livestock in resource degradation was still largely misunderstood in the broader world but that this ignorance resulted in negative effects being exaggerated. Methodologies need to be developed to study environmental issues. Proper presentation of results is also needed to avoid adverse criticism.

The effects of livestock on the environment may vary across ecoregions and care must be taken not to generalize. Degradation induced by fire, for example, is more important in savanna than in humid environments (Toutain).

Stock and flow concepts are important in degradation measurements. An area may appear degraded now but it is important to know when the degradation actually took place. In order to calculate the effects of livestock on the environment some objectives need to be set. These objectives may include changes in animal productivity, maintenance of soil status, net carbon stock and unchanged biodiversity. The state of each objective or criterion could then be measured as could the public and private sector response to such changes. Threats leading to pressures that are likely to change the state of an objective should also be identified. This needs to be done to increase the understanding of intervention capacities (Young).

A methodology needs to be developed to study environmental issues. Keeping silent is not the solution because others will keep on raising these issues (Peters).

Part two: Issues, constraints and opportunities for livestock development

Moderator

Tetsuro Komiyama

Rapporteur

Barry Shapiro

Macroeconomic, international trade and sectoral policies in livestock development: an analysis with particular reference to low income countries
Research and technology transfer for livestock development
Discussion sessions: Part Two

Macroeconomic, international trade and sectoral policies in livestock development: an analysis with particular reference to low income countries¹

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[Appendix A. Developing countries by geographical region](#)

¹ Research assistance by Fomakoye Adamou and Marcelle Thomas is gratefully acknowledged: order of authors' names was divided by successive tosses of a fair coin

Introduction

The livestock sector plays a vital role in the economies of many developing nations. It provides food, income, employment and valuable foreign exchange. In low income countries livestock also serve as a store of wealth, provide draught power and fertilizer for crop production and are a means of transportation. In 1991, livestock products accounted for about 15 per cent of agricultural GDP in developing countries in Southeast Asia [Appendix A contains a list of countries included in each region], 23 per cent in South Asia, 27 per cent in West Asia and North Africa (WANA), 28 per cent in sub-Saharan Africa (SSA), 37 per cent in South America and 43 per cent in Central America (USDA, 1993a). If the value of animal traction, transport and manure were added, the share of agricultural GDP contributed by livestock would be much higher.

Despite the importance of livestock, growth in output has been slow in relation to potential in many developing countries. Between 1979-1981 and 1992, per caput production of livestock and animal products declined by 10 per cent and 14 per cent in WANA and SSA, remained stagnant in Latin America and the Caribbean (LAC) but increased by 65 per cent in Asia (FAO, 1994a). Domestic supply of meat and milk has lagged behind demand in virtually all developing regions. Between the early 1970s and late 1980s, per caput meat consumption increased by 6 per cent in SSA, 32 per cent in LAC, 40 per cent in Asia, and 63 per cent in WANA (FAO, 1991).

Several factors underlie these trends. On the demand side, rapid increases in per caput income (especially in Southeast Asia), urbanization and high income elasticities of demand for livestock products have partly fuelled increases in per caput consumption. On the supply side, low animal productivity, inappropriate technologies, inadequate research and extension support, poor infrastructure and unfavourable external conditions (for example protection in developed countries) contribute to poor performance by the livestock sector. In addition to these factors policy choices by Governments in many developing countries played a significant role in widening the gap between domestic demand and supply.

Historically, governments in both developed and developing countries have intervened in the agricultural sector for political and economic reasons by a variety of instruments and institutional arrangements. In developing countries evidence suggests that macroeconomic and sectoral policies pursued in the past and the institutional instruments used to implement these policies stifled production by creating a pervasive anti-agricultural bias (in SSA) or encouraged inefficient production for the domestic market and reduced incentives for producers to look outward (in LAC and Asia). Some policies simultaneously made imported livestock products more available and affordable than domestically produced equivalents, thus encouraging inappropriate consumption (World Bank, 1981; Krueger *et al*, 1988; Jaeger, 1992; Williams, 1993a).

The economic and production inefficiencies spawned by these policies created structural and macroeconomic imbalances that were considered inimical to economic growth in developing countries. In line with the worldwide trend to reduced state control and intervention in economic activities there have been moves in many developing countries toward liberalization of markets and reform of sectoral, trade, and macroeconomic policies. This new attitude to economic policies and rethinking of the state's role in fostering agricultural development creates an opportunity and a challenge for policy research. Research is needed to assess the achievements of implemented reforms and identify lingering constraints and opportunities to rectify them.

This paper analyzes the implications of macroeconomic, sectoral and trade policies for the livestock sector with a view to

informing the policy debate on development, especially in low income countries. It describes the economic and institutional factors that influence livestock sector growth and the options available to policy makers to improve performance and reviews the impact of past and present policies on the livestock sector.

The focus is on production from ruminant livestock in sub-Saharan Africa, Asia and Latin America, although references are made to West Asia and North Africa and to poultry meat and pork when appropriate. Given the heterogeneity in production systems, institutions, and economic environments, some selectivity has been exercised in discussing policy issues affecting the livestock sector. The paper seeks to identify broad similarities and differences between regions and (where feasible) countries, in order to highlight patterns that form and constrain policy decisions in developing countries.

Trends in developing countries

Production

Livestock production in different regions differs markedly. Differences exist not only in production systems but also in the relative importance and potential for increased production by livestock species. Variations arise due to differences in resource endowment, climate, population, disease incidence, level of economic development, research support and government economic policies. Production trends are also difficult to measure because of the cyclical nature of meat supply. An accurate production measure would include both meat produced by slaughter and change in inventory but the data generally available are based only on slaughter figures. Sole reliance on slaughter figures often creates a bias in trends, particularly for cattle, since slaughter numbers and change in inventory vary inversely during the cattle cycle. Calculations of ruminant production trends are therefore usually sensitive to the choice of the time frame used in a trend analysis.

Ruminants provide the major share of meat produced in Latin America, sub-Saharan Africa and West Asia and North Africa whereas pigs and poultry provide the larger share in Asia (Table 1). Beef accounted for 52 per cent and 50 per cent by weight of total meat production in Latin America and sub-Saharan Africa in 1990-1999 but pork and poultry accounted for 80 per cent of meat production in Asia. In relation to world production, Latin America is an important beef region with 19 per cent of global beef output in 1990-1992. During the same period Asia produced about 42 per cent of world pork output but the four regions considered here accounted for only 23 per cent of global cow milk production.

Asia has shown rapid growth in meat and milk production in the last 10 years in contrast to slow growth in the other developing regions (Table 2). Production of red meat grew by 4.0-6.5 per cent in Asia but by only 1.0-2.8 per cent in LAC, SSA and WANA. Growth in red meat output in SSA and WANA has been below the population growth rates of 3.1 per cent and 2.9 per cent. Across regions, red meat production has grown more slowly than white meat, partly reflecting rapid industrialization of white meat production in many developing countries. Milk production grew at a higher rate than meat production in SSA but milk output expanded less than meat output in the other regions.

Consumption

Livestock output over the past 20 years grew more slowly than demand in many developing countries (Figure 1). Demand for meat, in particular, out-paced domestic supply by a wide margin. In the 1970s and 1980s the Asian region showed fastest growth in meat consumption among developing regions, most of this being in pork and poultry. Per caput increases in income, urbanization and changes in relative meat prices were the main determinants of higher meat consumption. Income has the greatest influence on demand for livestock products, demand increasing with higher incomes up to a certain level, after which it tends to stabilize before it declines at the highest incomes. East Asia and the Middle East show increased consumption accompanying economic growth. This is due to rapid industrialization in East Asia and increasing oil revenues in the Middle East.

Between 1969-1971 and 1986-1988, WANA showed a 63 per cent increase in per caput meat consumption. Reduced incomes cause reduced consumption or a switch to cheaper substitutes. Depressed growth in real incomes in Latin America during the 1980s, for example, caused a shift from beef and pork to cheaper poultry (Jarvis, 1986). A similar switch occurred from imported to local dairy products in several West African countries in the late 1980s (Williams, 1993b).

Table 1 Meat and milk production ('000 tonnes) by geographical region, 1969-1971 to 1990-1992

Product	Region and period							
	Sub-Saharan Africa		Asia		West Asia and North Africa		Latin America	
	1969-1971	1990-1992	1969-1971	1990-1992	1969-1971	1990-1992	1969-1971	1990-1992
Red meat								
Beef	1682	2269	2363	4005	681	1202	6779	9965
Lamb/Mutton	294	403	625	1184	761	1356	389	294
Goat	406	507	690	1626	307	352	87	123
Buffalo	-	-	997	2194	129	192	-	-
Subtotal	2382	3179	4675	9009	1878	3102	7255	10382
White meat								
Poultry	344	859	2367	6778	394	2061	1211	5883
Pork	189	470	11148	29534	18	37	1714	3039

Exports	38.2	48.5	0.5	2.0	0.2	0.6	0.1	0.0	0.6	2.5
Imports	81.3	105.1	3.7	7.1	39.7	74.6	4.1	11.3	184.0	129.4
Net	-43.1	-57.6	-3.2	-5.1	-39.5	-74.0	-4.0	-11.3	-183.4	-126.9
Asia										
Exports	68.4	182.5	33.7	32.5	74.8	345.7	97.6	325.7	20.6	55.8
Imports	102.1	349.2	37.4	94.0	109.5	400.0	40.8	79.6	484.5	607.3
Net	-33.7	-166.7	-3.7	-61.5	-34.7	-54.3	56.8	246.1	-463.9	-551.5
West Asia and North Africa										
Exports	5.9	18.0	29.2	14.2	24.5	16.0	0.0	0.0	1.6	5.8
Imports	314.0	416.5	268.8	140.6	613.5	441.2	0.2	0.3	358.6	449.2
Net	-308.1	-398.5	-239.6	-126.4	-589.0	-425.2	-0.2	-0.3	-357.0	-443.4
Latin America										
Exports	501.7	406.8	31.4	27.4	258.7	380.2	1.5	30.7	13.0	33.5
Imports	112.2	268.1	9.4	43.8	129.4	252.7	26.3	72.0	444.6	503.3
Net	389.5	138.7	22.0	-16.4	129.3	127.5	-24.8	-41.3	-431.6	-469.8

Source: Calculated from FAO production yearbooks and data tapes

Trade

Slow domestic growth relative to demand has led to increased imports and reduced exports. For 1990-1992, regional net meat imports in WANA, Asia and SSA were about 950,000, 282,000 and 148,000 tonnes per year (Table 3). In the period 1980-1982 to 1990-1992, Latin American beef exports fell by nearly 30 per cent while pork exports from Asia rose by over 200 per cent. Dry milk powder dominates dairy product trade in developing countries, commercial imports in 1990-1992 being highest in Asia and lowest in SSA, probably due to lack of foreign exchange in SSA and an increasing capacity of some countries in East and Southern Africa to produce the milk needed for domestic consumption.

These statistics conceal a lot of diversity between countries. It is clear, however, that with adequate income growth a huge potential for increased demand exists in developing countries given current low consumption levels, high income elasticities of demand and increased population and urbanization. Slow growth in livestock production in some countries and particularly in SSA is, however, a bottleneck to sector development. This implies that in addition to technical measures required to raise productivity revised policies are needed to create appropriate incentives to spur sector growth.

Importance of macroeconomic, trade and other policies in economic theory

Macroeconomic stability and growth

Economic prospects for animal agriculture in less developed countries are conditioned by the general economic performance impinging on agriculture and the rural sector. Concerns for technology, infrastructure and sectoral policies are frequently foremost in the minds of livestock producers and analysts. Economists, however, point to the equal if not greater importance of economic growth and macroeconomic policies (including trade, finance, and investment policies) to the development prospects of farm and other rural based activities in low income countries. Political economy factors in these countries often militate against the economic interests of rural communities and their often underestimated contribution to national output and economic welfare (Johnson, 1994).

Prudent macroeconomic policies are widely recommended as the basis for an "enabling environment" for growth and broad based gains in economic welfare. These policies include stable monetary growth, open and relatively flexible arrangements for international transactions and sustainable fiscal policies designed especially to avoid excess monetary expansion and not cause inflation.

For livestock, prudent policies assume particular importance given that the subsector involves assets that, analogous to durable manufactures, can be stores of value as well as inputs to production. Meat, milk and dairy products and eggs are also widely regarded as superior goods in consumption - that is, goods that increase in importance in consumption expenditure as household (and national) incomes rise (Mellor and Johnston, 1984). In this last connection, although production and especially consumption of livestock products might be expected to increase as income levels rise with economic development, it should be emphasized that the causality runs principally from economic growth and development on the one hand, to the livestock subsector, on the other. In other words, promotion of animal agriculture cannot usually be advanced beyond the pace of general economic development except where fundamental economic factors enable a country to specialize in animal production and export the bulk of it to markets in higher income countries. Where foreign investment is allowed, some important constraints, such as availability of human capital and advanced production and other technologies, might also be alleviated, furthering the possibilities for development of animal agriculture where other fundamental factors (and economic policies) are favourable.

Policy biases against agriculture from the economywide perspective

Macroeconomic policies

Macroeconomic stability and economic growth are of fundamental importance to advanced as well as less developed countries and to the general performance of most production sectors within countries. In the context of animal agriculture in less developed countries a special concern is that inappropriate monetary and fiscal policies can give rise to a bias against agriculture and its most efficient subsectors. Specifically, disincentives to agricultural production and exports can arise when the pursuit of unsustainable expansionary monetary and fiscal policies result in an overvalued exchange rate, excessive imports and lower exports. The frequent outcome is that new import controls are imposed as foreign exchange reserves fall, "validating" the overvalued exchange rate and reinforcing the import-substitution policies. This outcome also results in the repression of incentives for greater exports of agricultural commodities and products, including livestock, that bulk large in the underlying comparative advantage of many less developed countries.

Protection trade policies

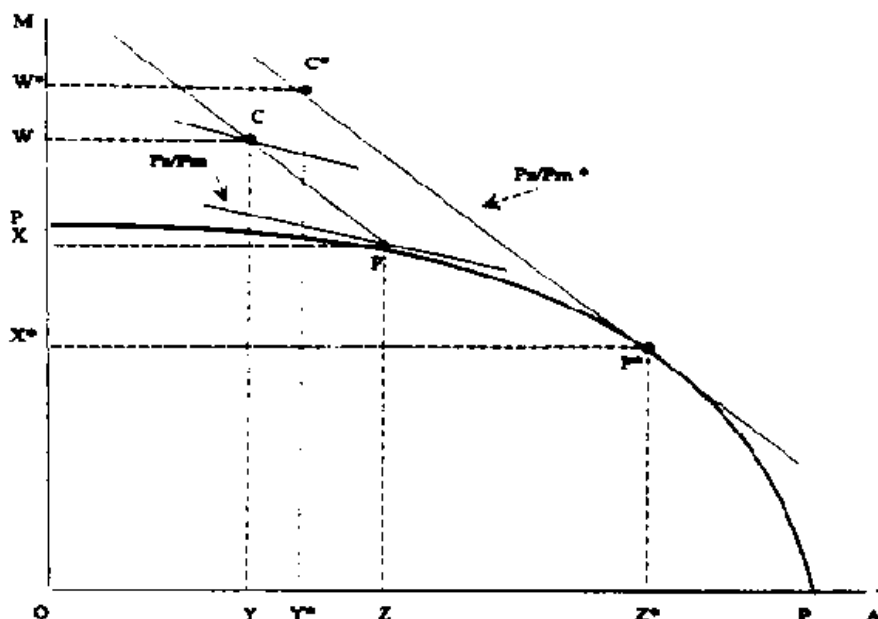
In the economywide perspective linkages among macroeconomic policies, protection and agricultural production and trade in less developed countries are at once complex and straightforward. Trade policies are often considered as macroeconomic policies due to their close relationship with the macroeconomic conditions for equilibrium in international payments balances. They can equally be regarded, however, as complex arrays of sector policies, frequently with the central purpose in low income countries of promoting industrialization or other development objectives, such as increasing export diversification.

Import substitution policies promoting industrial or other subsectors, including non-competitive subsectors of agriculture itself, essentially result in distortions to domestic relative prices that discourage production and greater exports of internationally competitive goods. These are traditional and other goods that use a given country's (relatively) abundant resources most intensively. Agricultural production and exports frequently suffer when protection in developing countries is given to encourage industrial or other production. More generally the disincentives to agriculture will have a negative impact on the rural sector and forestall the greater contribution that robust performance in agriculture and the rural sector can make to economic growth in many less developed countries (Badiane, 1991; 1992).

The circumstances of the livestock and agriculture sector in less developed countries can be considered with reference to production and consumption possibilities in a "small" exporting country (Figure 2). The country produces both manufactures (M) and agricultural goods (A) but its stock of both natural and accumulated primary factors of production - land, labour, and capital (inclusive of human capital, technology and social infrastructure) - is assumed to support greater production of food and other agricultural goods than manufactures over a wide range of possible relative prices. At the given international terms of trade P_a/P_m^* the country maximizes its economic welfare by producing at point P^* and consuming at a point such as C^* . This involves the (balanced) international exchange of the country's excess supply of agricultural goods (exports, Y^*Z^*) to meet its excess demand for manufactures (imports, X^*W^*).

High rates of protection for industry, for political economy reasons or to support economic development objectives, are commonplace in developing countries, especially low income countries in Africa and Asia (Finger and Laird, 1987; Erzan *et al*, 1989; DeRosa, 1992). Introducing import substitution policies (in the form of an *ad valorem* tariff on imports of manufactures) results in production and consumption occurring at points such as P and C (Figure 2). The import substitution policy protects local industry and causes domestic terms of trade P_a/P_m to decline, thereby providing the incentive for producing and consuming a greater quantity of domestic manufactures. At the same time, by reducing domestic terms of trade to a point below the international terms of trade for agriculture P_a/P_m^* , the policy has the indirect effect of creating a "bias" against production (and exports) in the agricultural sector (Valdés, 1973; Cavallo and Mundlak, 1982; Krueger *et al*, 1988; Bautista and Valdés, 1993) within the framework of somewhat more sophisticated analytical models that incorporate consideration for the non-traded goods sector.

Figure 2 Equilibrium under free trade and protection



The foregoing analysis is highly stylized. To incorporate animal agriculture explicitly a multi-sector framework such as might be provided by a computable general equilibrium (CGE) model would be required as well as greater consideration of natural resource endowments and the factor requirements for producing animal products. In the mainly heuristic terms pursued here however, what is at issue is whether the livestock sector conforms more to the profile of the "disprotected" agriculture sector or more to that of the protected industrial sector previously described.

Animal agriculture is widely considered to have attractive attributes. It is widely practiced, at least informally, and offers a natural path for commercialization of farm activities in rural areas, even by low income households. Some animal operations, such as dairying and fattening, can be more labour-using (and land-saving) than other farm activities and on an expanded commercial basis require substantial inputs from other agricultural subsectors, especially feed grains. In regions of South Asia with limited arable land greater livestock production might thus efficiently absorb "under-used" labour and increase demand for "inferior" food grains, such as sorghum and maize. Processing of livestock products could absorb further labour but might need capital or technology inputs whose (relative) availability in developing countries is more problematic, especially where foreign investment by multinational or other foreign enterprises is prohibited or highly restricted.

From a normative in addition to the pursuit of prudent monetary and fiscal policies, the first-best remedy for overcoming the disprotection of livestock and other efficient subsectors of agriculture in low income countries is the reduction of protection for industrial and other sectors having little or no international comparative advantage. Such liberalization of trade policies also increases integration with the world economy, in effect allowing world relative prices for agricultural commodities to prevail in the domestic economies of low income countries. It should also be expected to provide such countries with greater benefits from multilateral agreements to liberalize world trade in agriculture, such as under the recently concluded Uruguay Round of multilateral trade negotiations.

Finally, in the real world of second-best policy options, it is frequently suggested that more sector specific improvements to regulatory regimes and infrastructure are to be preferred over macroeconomic and trade policy reforms. This is an area needing more analysis. Recent studies nonetheless indicate that, while inherently desirable, sector-specific policy reforms have limited capacity to overcome biases against agricultural subsectors as long as economic distortions related to macroeconomic and trade policies remain in force (Krueger *et al*, 1988; 1991).

Regional integration

Consequent on the overlong Uruguay Round meetings, renewed interest in preferential trading arrangements, mainly in the form of "free" trade areas, has surfaced in a number of developing regions (Table 4). The implications of such arrangements can be sketched using the analytical framework that has already been described (Figure 2).

Table 4 Organizations for economic cooperation in developing regions

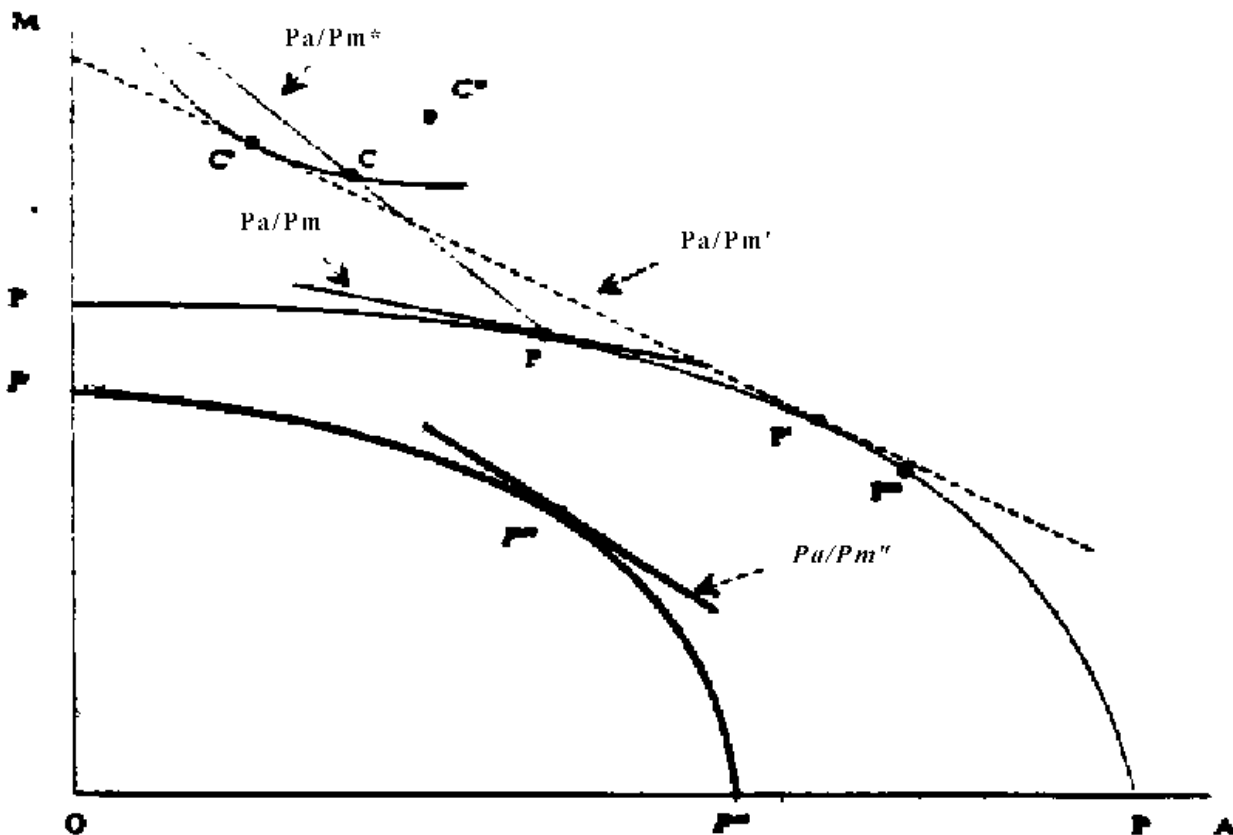
Region	Organization and member countries
Sub-Saharan Africa	Central African Customs and Economic Union (UDEAC): Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon
	Common Market for Eastern and Southern Africa (COMESA): Angola, Burundi, Comoros Djibouti, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia, Zimbabwe
	Economic Community of West African States (ECOWAS): Benin, Burkina, Cape Verde, Côte d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo

	Southern African Development Community (SADC): Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe
	Southern African Customs Union (SACU): Botswana, Lesotho, Namibia, South Africa, Swaziland
Asia	Asia Pacific Economic Cooperation (APEC): Australia, Brunei, Canada, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, United States, Taiwan, Thailand
	Association of Southeast Asian Nations (ASEAN): Brunei, Indonesia, Malaysia, Philippines, Singapore, Thailand
	South Asian Association for Regional Cooperation (SAARC): Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka
Latin America and Caribbean	Andean Common Market (ANCOM): Bolivia, Colombia, Ecuador, Peru, Venezuela
	Caribbean Community (CARICOM): Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, Montserrat, St Kitts-Nevis, St Lucia, St Vincent, Trinidad and Tobago
	Central American Common Market (CACM): Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua
	Latin American Integration Association (LAIA): Argentina, Bolivia, Chile, Colombia, Ecuador, Mexico, Paraguay, Peru, Uruguay, Venezuela
	Southern Cone Common Market (MERCOSUR): Argentina, Brazil, Paraguay, Uruguay
Middle East	Cooperative Council for the Arab States of the Gulf (GCC): Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates
	Council of Arab Economic Unity (CAEC): Egypt, Iraq, Jordan, Kuwait, Libya, Mauritania, Somalia, Sudan, Syria, United Arab Emirates, Yemen Arab Republic, Yemen PDR
	Economic Cooperation Organization (ECO): Iran, Pakistan, Turkey

Source: Union of International Associations, 1987

A trading arrangement can be formed in which one country (Figure 2) forms a free trade area with another country from the same region (Figure 3). Production possibilities of the second country are represented by the *PP* curve, which portrays the second country as nearly identical to the first in terms of relative resource endowments. The production possibilities of the two countries differ in scale, however, reflecting an underlying difference in the absolute size of their respective endowments of primary factors of production. Like the first country, the second is assumed to forgo production at the free trade point *P** and to enforce import restrictions that promote greater domestic production of manufactures. Equilibrium production under protection thus occurs at point *P* at the domestic terms of trade *Pa/Pm*, which are lower than the international terms of trade *Pa/Pm**.

Figure 3 Equilibrium under a regional trading arrangement



The terms of trade governing production and consumption in the first and second countries, *Pa/Pm* and *Pa/Pm*, are not

necessarily the same. Their relative magnitudes depend principally on the restrictiveness of the trade measures enforced in the first versus the second country. If protection levels are the same in both countries relative prices will be the same and there will be no incentive for intraregional trade. If, however, the first country maintains a higher (lower) level of protection than the second, the relative price of agricultural goods will be lower (higher) in the first than the second country and there will be incentive for trade between the two either officially or unofficially. Specifically, the first country will tend to exchange exports of agricultural goods (manufactures) for imports of manufactures (agricultural goods) as $P_a/P_m < (>) P_a/P_m$.

Under a free trade arrangement between the two countries trade with third countries (i.e. countries outside the regional trading bloc) would be diverted to a greater or lesser degree. Assuming no barriers to trade except political ones the domestic terms of trade in the two countries would converge to a level between P_a/P_m and P_a/P_m in order to accommodate the adjustment of production, consumption, and trade. Economic welfare in the two countries, would not necessarily be improved. The well being of the first country is not improved unless the intrabloc terms of trade are greater than P_a/P_m' (Figure 3), in which case the new equilibrium point for production would lie between P' and P^* and the new equilibrium point for consumption would occur at a higher level of (national) economic welfare than that corresponding to point C.

These results demonstrate the fundamental importance of the complementarity of relative factor endowments and hence differences in comparative advantage among countries forming a preferential trading arrangement. If the first country allies itself with one or more countries that have relative factor endowments very similar to its own - i.e. other agricultural exporting countries - the intrabloc terms of trade are unlikely to exceed P_a/P_m' appreciably. Only if the alliance is one in which the member countries are marked by considerable complementarity of natural and accumulated factor endowments would the regional trading arrangement be likely to result in a significant reduction in the bias against agricultural production and trade and to yield an appreciable improvement in economic welfare. This is ironic because in such circumstances members of the trading alliance would be more likely to enjoy terms of trade approximating those available to them under free trade - i.e. P_a/P_m^* .

In addition, the expansion of production and trade in agriculture is principally in the domain of the first country. Given initial relative prices in the two countries under protection, the first will expand production and exports of agricultural goods but the second will specialize further in the production and export of manufactures. Though both countries might thus have an underlying comparative advantage in agriculture from a world vantage the preferential trading area in fact contributes to overcoming the bias against agriculture only in the first country although the regional trading arrangement might improve economic welfare in both countries.

Extension of these results to production and trade in livestock products is not entirely straightforward. In broad terms regionalism might offer less developed countries an opportunity to expand mutual economic interests through preferential trading arrangements covering livestock products as well as other agricultural goods and manufactures. Fully articulating animal and other agricultural subsectors and greater opportunities for specialization and trade would clearly be introduced within a multisector framework. Nonetheless, the benefits of regional trade liberalization would still be more limited than those available to the countries under general trade liberalization. Further regional economic cooperation should not be expected to promote livestock production and exports widely in the region as long as resource endowment profiles among regional trading partners are similar.

Foreign trade barriers and structural impediments

Notwithstanding the insights from this simple analytical framework (Figure 2, Figure 3) recent research and pragmatic discussions of regionalism have both pointed to some substantive reasons why regional trading arrangements among developing countries might be given greater consideration.

First, the appreciable weakness of the international terms of trade facing exports from many developing countries (for example due to increased protectionism in the major industrial countries or, in the case of some commodity-exporting developing countries, the "dumping" of meat, dairy and other agricultural surpluses on world markets by industrial countries) sustains the view that greater integration with the world economy offers no clear advantages to less developed countries. As emphasized elsewhere (Wonnacott and Wonnacott, 1981: 1992), at the margin foreign protection and its contribution to unfavourable terms of trade for developing (or other) countries in the world economy make membership in regional trading arrangements more attractive by lowering the critical terms of trade P_a/P_m' (Figure 3) [high transport costs for shipments of exports or imports would have implications similar to those for high foreign rates of protection: on the importance of international transportation costs for sub-Saharan African countries, see Yeats, 1990]. Progress in liberalizing world trade in agriculture, following the Uruguay Round outcome, would be expected to make regional trading agreements less attractive by raising the critical terms of trade. Early analyses suggest that little was achieved by way of measurable short or long term improvements to the international terms of trade of livestock or other agricultural products (FAO, 1994; Ingco, 1994; Hathaway and Ingco, 1995).

Among other considerations shortcomings in both physical and institutional components of the infrastructure surrounding agriculture in developing countries could have major implications on the desirability of seeking regional trading arrangements.

Indeed, as documented in studies of structural impediments to greater agricultural productivity, the components of infrastructure surrounding agriculture are often seriously deficient in low income developing countries (Lele, 1991). This relates to transport and communications networks, rural credit markets, organization and regulation of agricultural input and output markets and legal or informal arrangements surrounding the tenure and property rights of individual economic agents over agricultural lands, waterways and irrigation systems.

As an example, poor rural transport or marketing networks in the second of two otherwise similar neighbouring countries (both pursuing import-substitution policies) would be expected to impair economic incentives for agricultural production in the second country, in effect foreshortening the production possibilities curve *PP* along the agricultural output axis (Figure 3). This would give rise to more sharply divergent relative prices in the two economies than depicted. Whether the creation of a free trade area would result in greater intraregional trade would depend, however, on the precise inadequacies of the infrastructure serving the rural economy of the second country. This would affect, in particular, how they might contribute under liberal trading arrangements to making intraregional trade more attractive to economic agents than wider international trade.

If, for example, overland routes from areas of surplus livestock or other agricultural production to markets in neighbouring countries are shorter or more passable than (say) main routes to port facilities for overseas trade, or if intraregional trade is not required to pass through a parastatal marketing system, then the free trade area would result in expansion of intrabloc trade and tend to eliminate the differences in the relative price of agricultural goods between the two countries. In other circumstances creation of a preferential trading area might lead to little appreciable expansion of trade or adjustment in domestic relative prices without simultaneous elimination of underlying structural impediments.

Macroeconomic policies, trade regimes and livestock development in developing countries

Macroeconomic policies

A "core sample" of 16 low income and other developing countries (Table 5) provides an overview of macroeconomic performance, agricultural and livestock production growth and monetary and fiscal policies during the 1970s and 1980s in six subregions of Asia, Latin America and sub-Saharan Africa. Indicators of macroeconomic performance include economic growth, inflation, and change in the inflation adjusted or real exchange rate. Those illuminating the progress of agriculture and livestock (meat only) comprise the real growth of production and exports. Indicators of macroeconomic policies are confined to the two variables of monetary growth and government expenditure relative to GDP. These indicators are far from comprehensive and, taken individually, are subject to a number of shortcomings including the reliability of the data that underlie their measurement. It should also be noted that statistics by region are based on representative but very limited samples of the countries in the six subregions.

Table 5 Economic performance, agricultural growth, and macroeconomic policies (all average annual percentage rates) by developing regions, 1970-1990

Item	Region (countries) and period											
	Southeast Asia (Indonesia, Malaysia, Philippines)		South Asia (Bangladesh India)		Central America (Guatemala, Honduras, Mexico)		South America (Argentina, Brazil, Venezuela)		Eastern/Southern Africa (Kenya, Zimbabwe)		West Africa (Côte d'Ivoire, Mali, Nigeria)	
	1970-1980	1980- 1990	1970- 1980	1980- 1990	1970- 1980	1980- 1990	1970- 1980	1980- 1990	1970- 1980	1980- 1990	1970- 1980	1980- 1990
Macroeconomic performance												
GDP growth	7.00	3.89	1.85	5.00	6.02	1.51	4.71	1.18	4.12	3.54	5.42	1.45
Per caput GNP (US \$) ^{a)}	930	1207	195	280	1360	1327	2700	2547	565	505	783	437
Export growth	5.55	5.91	2.30	6.46	7.56	0.95	1.51	2.14	0.36	1.38	4.31	3.66
Inflation	12.95	8.50	14.08	9.53	11.92	31.35	58.78	232.98	10.50	12.43	13.08	10.24
Real exchange rate change ^{b)}	-3.49	5.29	1.90	2.68	-1.13	4.42	-1.49	5.47	-2.16	4.26	-6.7	5.61
Agricultural performance												
Agricultural production	4.35	2.67	1.20	2.93	2.70	1.88	3.37	2.22	2.68	2.87	2.27	1.66
Agricultural exports	-0.17	-0.30	-1.87	1.21	2.85	0.59	-4.88	6.00	-0.01	4.41	-4.23	1.53
Meat production	3.85	7.03	1.66	3.56	3.78	0.54	4.37	1.74	2.66	2.85	5.09	1.68
Meat exports	-18.24	39.44	23.91	2.78	1.39	-1.44	2.28	0.14	-6.74	-3.44	5.13	-8.17
Macroeconomic policies												
Money supply growth	27.33	18.86	18.97	15.85	20.44	30.17	49.87	185.86	19.84	17.25	25.04	9.55
G'ment expenditure/GDP	14.02	15.65	10.83	13.75	9.43	14.52	14.68	19.04	22.91	27.67	10.58	16.42

Notes:

a) Per caput GNP in 1980 and 1990

b)

Regional country currencies vis a vis US \$

Sources: UNCTAD, 1992; FAO, 1994c; World Bank, 1994a (data are derived as simple averages of country data by region)

The subregions are about equally divided into middle and low income areas. Middle income countries (GNP > US \$ 1000 per caput in 1990) are mainly in Southeast Asia and the Latin American subregions. GDP growth was generally greater than 4.0 per cent per annum during the 1970s except in South Asia where it was just under 3.0 per cent. Inflation and exchange rate changes are remarkably similar across the subregions (Table 5). Inflation was in the range 12.0-15.0 per cent per annum except in South America where it averaged nearly 60.0 per cent. In all subregions the inflation-adjusted exchange rate tended to appreciate during the 1970s with the steepest average rates recorded by West Africa and Southeast Asia. Notwithstanding the trend in real exchange rates export growth was generally positive with highest average rates in Central America and Southeast Asia and lowest rates in South America and Eastern and Southern Africa (Table 5).

In comparison to GDP growth the average growth of agricultural production in the 1970s was generally more modest at 2.0-3.0 per cent annually, except in Southeast Asia where it exceeded 4.0 per cent and South Asia where it was just over 1.0 per cent (Table 5). Average growth of agricultural exports was positive only in Central America. In the other subregions it was strongly negative.

The generally weak performance of agricultural production and exports might be taken as symptomatic of the bias against agriculture in the sample countries, depending on the precise nature of the macroeconomic policy environment of the countries surveyed. It needs to be noted, however, that growth rates of meat production and, to a lesser extent, meat exports were frequently more robust than those of general agricultural production and exports during the 1970s (Table 5), presumably reflecting aggregate economic growth but possibly also protection for the meat subsector from import competition. The data suggest that during this period production of meat in some subregions, especially in Latin America, was oriented towards the domestic market as indicated by the higher average growth rates of production than exports.

The 1980s are often referred to as the "lost decade" for developing countries because of lower rates of economic growth, frequent balance of payments problems and sharp (real) exchange rate adjustments. These economic difficulties are reflected dramatically in the actual decline of per caput income levels between 1980 and 1990 in the Latin American and sub-Saharan Africa subregions (Table 5).

From a macroeconomic policy perspective many developing countries failed to curb their large monetary and fiscal imbalances during the 1980s in response to reduction in monetary growth and increased emphasis on achieving greater economic efficiency and international competitiveness in the USA and other major industrial countries. Indeed, monetary growth and government expenditure (relative to GDP) increased - or were not reduced sufficiently - in several subregions (Table 5). This placed many countries at a considerable disadvantage as economic policies in a world economy dominated by industrial countries shifted gear abruptly and encouraged international flows of financial resources to fund higher rates of investment in the major industrial countries than they had during the 1970s.

The strength of such international economic forces combined with policy adjustments taken reluctantly in many less developed countries during the second half of the 1980s caused real exchange rates to adjust to lower levels in most developing regions during the 1980s. Economic growth matching that during the previous decade could not be achieved in the developing subregions except for South Asia, which increased its average rate of GDP growth from 2.9 per cent to 5.0 per cent. Aggregate growth of exports, on the other hand, improved appreciably in several areas. This included South America where, in association with the sharp average depreciation of the real exchange rate (5.5 per cent), it increased from 1.5 per cent to 2.1 per cent per annum. Improved export performance, except in South Asia and Central America, was "led" by improved growth of agricultural exports.

Growth rates of agricultural production and exports fell in Southeast Asia while growth rates of meat production rose relative to the previous decade. Agricultural exports rose sharply in both South America and West Africa but average growth rates of agricultural production, meat production and meat exports fell relative to the previous decade. Against the record of these three subregions, however, two bright spots are seen in the economic performance of South Asia and Eastern/Southern Africa, where growth rates in output and exports of both agricultural products and meat were marginally or substantially higher than during the 1970s.

In summary, the 1980s witnessed greater disarray rather than added growth and development in agriculture and livestock in most developing regions. This might be attributed in part to changes in the international macroeconomic environment but failure by many developing countries to adopt more prudent macroeconomic policies under the changed international conditions are also an important factor. This lends weak support to the view that such policies in the domain of developing countries themselves are vitally important to achieving robust growth in the most internationally competitive subsectors of agriculture in less developed countries.

Relationships between macroeconomic policies and agriculture sector performance, especially the livestock sector, are complex and not easily captured by simple statistics. In addition, trade and sectoral policies should be factored into the analysis. An overriding issue with respect to this discussion of macroeconomic policies, however, is the continuing uncertain progress of policy reforms in many low income and other developing countries, as typified by a recent financial crisis in Mexico. Possibly of greater consequence, however, is the uncertain progress and sustainability of reforms being undertaken by developing countries elsewhere, especially in South Asia and sub-Saharan Africa. The experience of developing countries in several subregions during the 1990s with regard to macroeconomic policies and performance will determine the epitaph of the 1990s

Trade policies

World trading environment

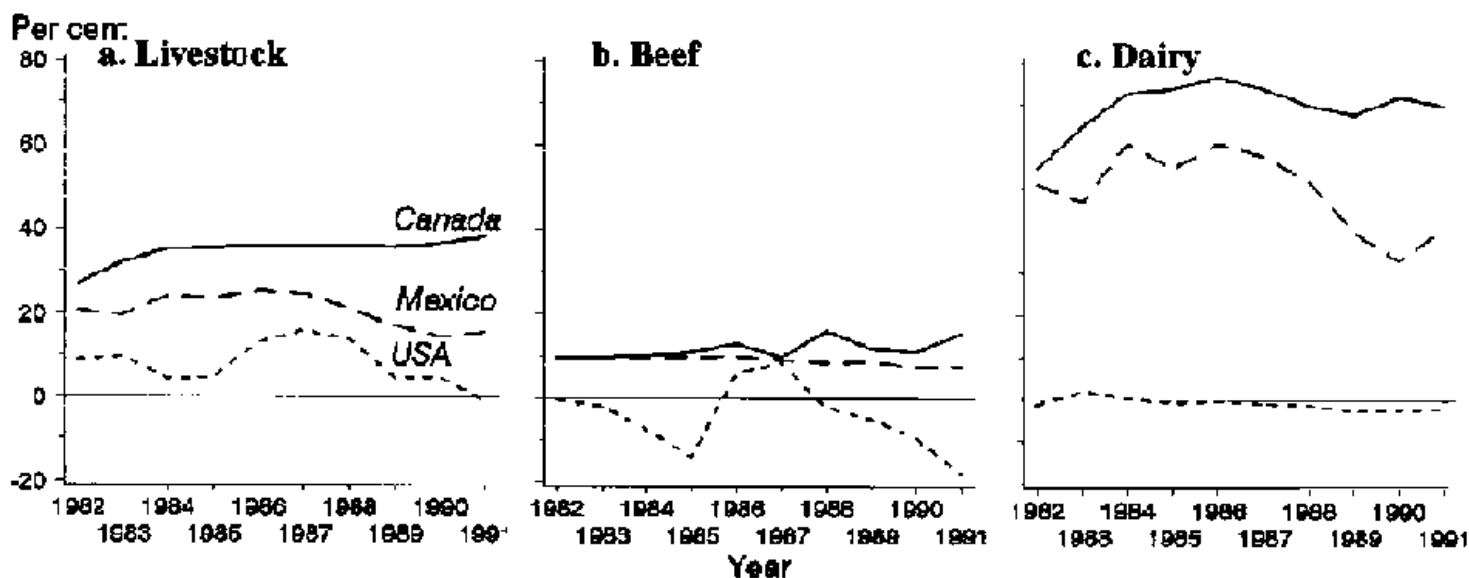
The global trading system is dominated by the major industrial countries. Expanding trade relations around the Asia-Pacific Rim - an especially dynamic region of the world economy that includes the fast-growing and outward oriented (newly) industrialized countries (NICs) of East and Southeast Asia - have, however, become a major factor in the growth of world trade during the last 10 or more years. The importance of the major industrial countries to the global trading system extends particularly to international trade in agriculture, which occupied a prominent place in the Uruguay Round of multilateral trade negotiations.

With respect to livestock, international trade in meat and dairy products takes place in a relatively small residual market and the volume traded accounts for a very small proportion of world production. Excluding trade among EU member countries, only about 10 per cent of global beef output, 5 per cent of dairy, 3 per cent of pork and 8 per cent of poultry were traded internationally in 1991 (World Bank, 1993) but even adding trade in the EU raises the percentage only slightly. Over 70 per cent of international trade in dairy products is through the EU, New Zealand and the United States. The EU is the largest beef exporter, accounting for about 26 per cent of world exports in 1991 with Australia contributing another 21 per cent. Some of these countries are also major importers, the USA taking 31 per cent of world beef imports in 1991, the EU 12 per cent and Japan 15 per cent. In an environment dominated by a few market participants world price movements and expectations are largely determined by the domestic meat and dairy policies of the key producing countries.

Concerns for food security and the secular trend of declining importance of agriculture in national output in developed countries have caused agricultural producer support policies to flourish (Figure 4). These are enforced by import controls as well as direct market interventions to maintain high prices for domestic farmers. These policies impose high and increasingly transparent costs on consumers and taxpayers. In the context of global trade relations they have also come to have important spill over effects on efficient producers in other countries, including less developed countries. The agricultural price raising policies of the major industrial countries succeeded in inducing over production in many EU countries and the USA. This has weakened world prices for meat, poultry and dairy products (and other agricultural commodities) indirectly via the effects of import controls and directly by dumping of excess government commodity stocks and officially subsidized exports -butter exported from the EU in 1994 needed a subsidy of almost US \$ 2000/tonne and non-fat dried milk a subsidy of almost US \$ 1000.

The world fresh meat trade is also faced with non-tariff barriers based on health restrictions. The EU bans meat produced with growth hormones but the most important restrictions are those on meat imports from countries where there is foot and mouth disease. Combined with domestic farm and livestock support policies the restrictions promote segmentation of world markets for livestock and lead to exclusion of most developing country exporters from the lucrative markets of industrialized countries.

Figure 4 Protection of the livestock sector (PSEs) in major exporting countries (Source: USDA, 1994)



Trade in processed meat and dairy products is not exempt from these difficulties. Few developing countries now export processed meat. Expansion of exports of higher value added meat and dairy products is, however, one way of overcoming barriers to the fresh meat trade and raising foreign exchange earnings. Protection of food processing industries in developed countries has its own peculiar features. In addition to tariffs and quantitative restrictions processed products from developing countries face two further barriers: non-tariff ones due to differing health, food safety and environmental standards; and structural ones due to domination of developed country food markets by

oligopolistic firms benefiting from major economies of scale and scope. A review of trade barriers to processed food exports from developing countries (Matthews, 1994) concluded that rising standards in developed countries will make it more difficult for developing countries to gain access and thus compete in terms of scale economies and product quality.

The Uruguay Round

The Uruguay Round was historic because negotiations to liberalize world agricultural trade were on the agenda. The industrial countries have made dramatic advances in liberalizing trade in manufactures in periodic rounds of negotiations of the General Agreement on Tariffs and Trade (GATT). Until the advent of the Uruguay Round, however, agriculture was largely outside efforts to expand international trade under GATT principles. The Round sought to curb, if not eliminate, protectionist policies. Drawn out over seven years, negotiations on agriculture proved to be very difficult and were not concluded until December 1993, after special bilateral understandings were reached between the EU and the USA. The agreement on agriculture concerns three principal areas: market access; domestic support policies; and export competition.

Market access

The major triumph is tariffication of all non-tariff barriers and the stipulation of an average 36 per cent reduction of bound tariff rates over the 6-year period of the agreement. Rules established for tariffication are not precise and, as a consequence, high rates of tariff protection are expected to be bound by many countries. Circumventing this problem in part is the additional requirement that minimum access be guaranteed for previously restricted import categories amounting to three per cent of domestic consumption initially and five per cent at the end of the implementation period (ironically, this requirement promotes establishment of tariff-rate quota systems in direct contradiction of basic GATT principles).

Domestic support policies

Domestic subsidies subject to control under the agreement are to be reduced by 20 per cent over the agreement period.

Export competition

Expenditure on subsidies and volumes of subsidized exports must be reduced by 36 per cent and 21 per cent over the period of the agreement.

These terms apply mainly to industrial and advanced developing countries. For other developing countries the Uruguay Round agreement on agriculture is less stringent under the rubric of "special and differential treatment" for less developed countries. In the main, the period of adjustment to the new multilateral trading regime in agriculture is extended to 10 years. Subsidies accorded to food and agriculture sectors for "development purposes" are also exempt from coverage. With the exception of tariffication, therefore, requirements for compliance to the terms of the agreement by less developed countries are limited.

Early estimates of the impacts of liberalization of industrial country farm policies based on simulations of multisector partial equilibrium and general equilibrium models (Burniaux *et al* 1990; Page *et al*, 1991) indicate that the total volume of agricultural exports by efficient producers will expand by about 25 per cent. This would be accompanied by an increase in the aggregate level of world prices for agricultural products of 10-15 per cent.

Under the terms of the new agriculture agreement changes in international trade and prices will be considerably smaller. Precise estimates are not available but, *ceteris paribus* the long run expansion of trade in agriculture by efficient exporters in response to greater market access is not expected to be more than 5-10 per cent. The long run increase in world prices for agricultural commodities is not expected to be more than 2-5 per cent in the aggregate and 5-10 per cent for some subgroups, including meat and dairy products as well as wheat (Table 6).

Some commitments were made by the EU and US to reform border measures distorting trade in agriculture (Table 7). Beyond illustrating the observance of the letter of the new trade agreement they reveal some important and disquieting elements. With regard to the tariffication of import barriers it is apparent that tariff rates have been widely bound at initial (1995) levels above the tariff equivalent rates of the pre-Uruguay Round non-tariff barriers.

In the case of milk products, for example, the EU and the USA raised initial protection levels substantially above pre-Round levels. Although the EU commitment implies a 29 per cent reduction in import controls by the year 2000, the end-period rate is actually 18 per cent higher than the pre-Round level. In respect of pledges of reduced volumes of subsidized exports the percentage reductions are inflated by the fact that, by agreement, they are measured relative to the average levels of 1986-1990 rather than the higher volumes of subsidized exports anticipated to take place in 1995.

Table 6 Simulated long-term effects (per cent) of agricultural trade liberalization on world prices

Commodity	Data source				
	WIDER, 1990	Page <i>et al</i> , 1991	FAPRI, 1993	Brandao and Martin 1993	Goldin and Mensbrugge, 1993
Temperate zone products					
Wheat	7.5	5.0	6.3	6.3	5.9
Coarse grains	3.4 ^a	1.8	2.4	4.4	3.6
Rice	18.3	1.2	4.4	4.2	-1.9

Meat	13.0	5.3	0.5	6.1 ^{f)}	4.7 ^{h)}
Sugar	10.6	5.0	-	10.2	10.2
Soya beans	0.0	-	4.5	-	-
Soya bean oil	0.1	-	3.8	-	4.1 ⁱ⁾
Dairy products	-	9.3	6.9 ^{e)}	10.1	7.2
Tropical products					
Coffee	0.4 ^{b)}	0.8	-	0.41	-6.1
Cocoa	0.0 ^{c)}	1.0	-	0.14	-4.0
Tea	0.5	-	-	2.34	3.0
Tobacco	0.3 ^{d)}	-	-	-	-
Cotton	0.9	-	-	2.23	3.7
Groundnuts	1.5	-	-	4.52 ^{g)}	-
Groundnut oil	0.6	-	-	-	4.1 ⁱ⁾
Plant and flowers	-	1.0	-	-	-
Spices	-	0.2	-	-	-

Notes:

- a) Simple average of maize and sorghum
- b) Beans (0.0 per cent for roasted, 1.4 per cent for extract)
- c) Butter
- d) Leaves (0.1 per cent for cigarettes, 0.8 per cent for cigars)
- e) 0.5 per cent for butter, 0.8 per cent for powder, 1.8 per cent for chocolate
- f) Beef, veal and sheep meat (3.1 per cent for other meats)
- g) All oilseeds
- h) Beef, veal and sheep meat
- i) All vegetable oils

Source: FAO, 1994c

Table 7 Uruguay Round commitments by the European Union and United States

Region and product	Type of commitment							
	Import controls (<i>ad valorem</i> tariff equivalent, per cent)				Export subsidies (volume of subsidized exports, '000 m.t. ^{a)})			
	1986-1988	1995	2000	Reduction	1986-1990	1995	2000	Reduction
	1	2	3	3-2/2	5	6	7	7-6/5
European Union								
Wheat	106	170.1	108.5	36	17008	19119	13436	34
Coarse grains	133	189.3	121.3	36	12625	12183	9973	17
Rice	153	360.5	230.6	36	184	177	145	17
Sugar	234	297.0	279.0	6	n/a	n/a	n/a	n/a
Beef and veal	96	96.1	86.9	10 ^{b)}	1034	1119	817	29
Pork	40	52.9	33.7	32 ^{c)}	509	491	402	17
Poultry	40	52.9	33.7	36 ^{c)}	368	440	291	40
Dairy	177	288.5	204.8	29 ^{d)}	n/a	n/a	n/a	n/a
United States								
Wheat	20	6.0	3.8	36	18382	20328	14522	31
Coarse grains	4	8.3	2.1	74	1975	1906	1561	17
Rice	1	5.2	3.3	36	49	272	39	476
Sugar	131	197.3	167.6	15	n/a	n/a	n/a	n/a
Beef and veal	3	30.6	26.0	15 ^{b)}	n/a	n/a	n/a	n/a
Pork	6	4.2	2.7	36 ^{c)}	n/a	n/a	n/a	n/a
Poultry	6	4.2	2.7	36 ^{c)}	35	34	28	17
Dairy	132	143.7	122.1	15 ^{d)}	n/a	n/a	n/a	n/a

Notes:

- a) Last column expressed in per cent

- b) Meat
- c) Other meat
- d) Milk

Source: Hathaway and Ingco, 1995

These disquieting elements of the GATT agreement, together with lowered expectations about quantitative estimates of the more general effects on international trade and prices of agricultural commodities, may be disappointing. Many agricultural and trade policy analysts, however, point to the success of the Uruguay Round in finally bringing agriculture into greater conformity with the basic principles of GATT and to the potential of future multilateral trade negotiations for achieving greater liberalization of trade in agriculture (Josling *et al*, 1994; Sanderson 1994). Against this view must be weighed that of critics who point to the unabated strength of administered arrangements in agriculture left in place by the Uruguay Round agreement and the creation of new administered arrangements in the tariff-rate quotas mandated under the market access provisions of the new agreement. To these critics, future negotiations to liberalize trade in agriculture will continue to be hindered by the still effective political consensus in favour of agricultural support programmes in the major industrial countries.

Protection in developing countries

The outcome of the Uruguay Round negotiations leaves room to doubt that appreciable expansion of international trade in animal products or other farm products will occur in the near future, at least directly in relation to the multilateral agreement on agriculture. Indirectly it is possible that world demand for agricultural goods might be increased through opportunities for expanded trade in textiles and other manufactures, or even services, made possible by the larger agreement.

This leaves for greater consideration the trade regimes of developing countries themselves especially those seeking to expand exports of livestock and animal products as well as other traditional and non-traditional agricultural commodities and goods (Table 8). The portrait is, however, deficient in several respects. First, regional summaries reflect the circumstances of the core countries and not of all countries in each region. Second, summaries of non-tariff barriers do not include consideration of foreign exchange restrictions which are vital to understanding the breadth of barriers to trade (including animal disease and other health and sanitary regulations that are sometimes enforced in a discriminatory manner against imports) in many African and other low income countries. Third, the data are incomplete with respect to trade in categories other than animal products, cereals and total trade owing to deficiencies in the underlying data sources. Notwithstanding these limitations, some aspects of the data are noteworthy for their possible implications for livestock development across the six subregions.

Judging principally by the height of national tariff walls the most protected economies are those in South Asia and South America whereas the least protected are Central America and Southeast Asia. African economies fall somewhere in the middle with average tariff rates on imports of manufactures as well as primary commodities falling in the range 25-33 per cent. With regard to livestock and animal products it is notable that tariff escalation occurs widely across regions with meat, dairy products and eggs generally facing substantially higher applied tariff rates than livestock. In addition, not unlike the circumstance surrounding imports of cereals and cereal preparations, restrictions on imports of animal products are frequently enforced by non-tariff barriers, including state trading monopolies as well as various forms of quantitative restrictions. In economic terms such restrictions are especially costly because, unlike (*ad valorem*) tariffs, they interfere with the efficiency of the price system in allocating resources as well as goods in consumption and production.

The height of the barriers against imports of animal products suggests that consumers in developing regions bear higher than necessary economic costs in meeting their demands for these products. In other words, lower import barriers - especially to imports of higher value meat, dairy and poultry products - would tend to lower costs of these food items to consumers. They would also, of course, expand opportunities for greater trade to producers of these commodities in other developing countries as well as in the major industrial countries.

Consistent with the earlier discussion of economic theory the possible bias against greater production and trade in livestock and agriculture in general can be related to the higher rates of protection for manufactures than for livestock and agricultural raw materials. Essentially, import substitution policies favouring industrial activities (but also possibly some staple food sectors such as cereals) limit economic incentives for greater specialization in the agricultural activities for which less developed countries (and subregions) have a strong underlying comparative advantage. It could be argued that countries in several of the subregions might enjoy greater output and exports of livestock and related products under more liberal trade policy regimes. Possibilities for such expanded production and exports include livestock in Southeast Asia and Central America, meat products in South Asia, South America and Eastern/Southern Africa and dairy products and eggs in Southeast Asia and South America.

Finally, with regard to regional trade relations, the data clearly show that the strongest trading ties of the six subregions in livestock and animal products are with the major industrial countries, especially with respect to imports. In the case of exports, livestock and meat exports from Central America are also destined mainly for markets in the more advanced countries. This leaves exports of dairy products and eggs and, to a lesser extent, livestock as the animal subsectors in which trade is conducted relatively extensively with other developing countries, presumably mainly on an intraregional basis given the high transport costs for livestock and the perishability of dairy products and eggs.

Table 8 Import restrictions and trade in livestock and animal products by developing regions, 1985

Region tariffs and trade ^{a)}	Product type							
	Primary products						Manufactures	All goods
	All	Live animals	Meat	Dairy products, eggs	Cereals	Agricultural raw materials		
Southeast Asia (Indonesia, Malaysia, Philippines)								
Tariffs and paratariffs	18.4	12.8	23.9	19.5	18.2	15.1	23.0	21.8
Non-tariff barriers	14.8	66.7	64.9	42.8	62.2	42.0	47.5	47.8
Imports, total		29.3	86.8	244.4	1014.8			27927.0
LDCs		8.2	30.5	5.0	407.0			10265.0
Exports, total		26.7	15.8	23.3	56.4			38619.0
LDCs		26.6	7.1	21.8	35.8			12331.0
South Asia (Bangladesh, India)								
Tariffs and paratariffs	100.2	74.8	150.0	72.1	54.9	87.6	122.8	116.3
Non-tariff barriers	73.4	91.7	100.0	92.7	95.9	88.8	61.7	65.1
Imports, total		7.8	1.1	120.6	490.5			18855.0
LDCs		6.7	0.1	22.6	243.0			6964.0
Exports, total		16.4	39.7	2.0	35.3			9264.0
LDCs		16.4	22.0	2.0	13.4			2519.0
Central America (Guatemala, Mexico)								
Tariffs and paratariffs	17.2	12.3	25.5	18.8	19.3	10.5	20.3	19.5
Non-tariff barriers	13.9	2.8	7.2	26.0	49.3	9.4	8.2	10.1
Imports, total		166.2	132.5	174.4	706.6			14825.0
LDCs		3.2	13.4	3.6	122.3			1353.0
Exports, total		155.0	37.7	2.3	20.1			23218.0
LDCs		11.1	10.0	2.2	6.7			2523.0
South America (Argentina, Brazil, Venezuela)								
Tariffs and paratariffs	45.7	31.8	47.0	59.9	49.7	47.3	53.2	50.5
Non-tariff barriers	24.3	20.0	26.6	64.8	23.1	12.9	41.9	37.1
Imports, total		35.2	51.9	108.0	1598.6			25453.0
LDCs		4.0	38.6	15.8	378.2			10298.0
Exports, total		6.3	1230.5	21.5	2307.4			48220.0
LDCs		3.1	435.7	5.7	842.5			14121.0
Eastern/Southern Africa (Kenya, Zimbabwe)								
Tariffs and paratariffs	30.2	10.5	36.3	38.4	29.9	28.7	33.9	32.9
Non-tariff barriers	37.3	50.0	57.2	80.6	58.4	26.7	33.8	34.9
Imports, total		0.4	0.2	4.9	156.3			2330.0
LDCs		0.0	0.1	0.0	65.4			872.0
Exports, total		0.2	31.7	0.1	23.6			1914.0
LDCs		0.0	3.0	0.1	5.8			724.0
West Africa (Côte d'Ivoire, Nigeria)								
Tariffs and paratariffs	22.6	12.8	29.0	27.1	25.1	15.7	25.2	24.6
Non-tariff barriers	16.7	5.6	42.9	33.1	41.1	6.7	10.0	11.8
Imports, total		5.7	15.7	121.5	450.8			7916.0
LDCs		0.4	1.7	0.8	64.4			1603.0
Exports, total		0.0	0.3	0.7	11.9			16048.0
LDCs		0.0	0.0	0.6	11.9			2321.0

Notes: a) Tariff and paratariff values are *ad valorem* rate (per cent) of tariffs plus import surcharges, import surtaxes and other fiscal charges levied on imports; non-tariff barriers are frequency (per cent) of national tariff lines so affected; imports and exports are millions of US \$

Source: UNCTAD, 1989

In the context of regional cooperation and possibilities for expanding intraregional trade in livestock and animal products an attractive option for regional policy makers would be the introduction of preferential tariff rates for intraregional exports of dairy products and eggs. This would be encouraged by regional producers recognizing their mutual interests in cooperative trade policies to promote exports to neighbouring countries at the (seeming) expense of exports from outside the region. Indeed, this policy option runs parallel to the focus of many regional trading arrangements among less developed countries on expanding intraregional trade in manufactures. From the economywide perspective, however, the extent to which preferential trading to promote intrabloc trade in industrial or other nontraditional sectors relieves

constraints on the scarcest resources and enables greater aggregate consumption to be achieved is of primary importance for economic welfare. In these terms, policies to expand intrabloc trade in sectors for which the region may have limited international comparative advantage are not likely to yield appreciable gains in economic welfare except to the regional producers whose economic interests are principally served by the preferential trading arrangements. Notwithstanding distortions in the global trading system that adversely affect the less developed countries, the second-best policy option, as well as the first-best, for the national economies of developing countries and those subsectors of agriculture that are most internationally competitive is likely to be general liberalization of trade with countries outside and within the same region on a nondiscriminatory basis.

Livestock sector policies

In addition to the economywide policies already discussed direct livestock sector specific interventions in developing countries are common and take many different forms. Traditional methods of intervention in the livestock sector include the use of price controls and state monopoly marketing boards, restraints on private sector involvement in processing and marketing and an array of inhibitory measures such as export taxes, import tariffs, export and import licenses, quotas and bans. These intervention policies were often implemented with the aim of achieving certain broad objectives including output expansion, export promotion, revenue generation, price stabilization, inflation control and improvement of income distribution. With few exceptions, however (e.g. Operation Flood in India), the evidence suggests that traditional methods of intervention in the livestock sector have failed to achieve their objectives and have, instead, largely benefited consumers at the expense of producers (Jarvis, 1986; Williams, 1993a).

Failure of traditional intervention methods stems in part from the inherent conflicts that often arise between the desired objectives of livestock policy and the instruments required to achieve them. In many LAC and SSA countries, for example, state marketing boards were established in part as instruments of revenue generation and producer support and to control export of livestock products. They functioned as buying and selling agents. At government prompting they often fixed low purchase and selling prices or used export earnings to subsidize and lower the urban retail price of meat and dairy products - thus benefiting consumers and harming producers. In cases where agency domestic selling prices (set by government) were inadequate to cover their handling costs and the costs of purchasing products at the government-guaranteed producer prices, subsidy payments were made by the treasury. In Zimbabwe in 1984 and 1986, for example, the Cold Storage Commission (the parastatal responsible for beef marketing) needed 8.5 million and 6.0 million Zimbabwe dollars to cover trading deficits incurred as a result of government control of both purchase and wholesale selling prices (Williams, 1993a).

There was similar inadequate appreciation of the potential conflict involved in attempting to achieve domestic livestock production objectives through the price mechanism and maintaining external trade balance. The traceable nature of livestock products implies that if stiff tariffs or quotas are imposed on imports to correct trade imbalances created by an overvalued exchange rate they will often have an indirect ill effect on the livestock sector since they were not implemented with the latter in mind.

Previous intervention policies also failed to account for the dynamic behaviour of the livestock sector and the role that other institutional factors such as credit and public infrastructure could play in promoting livestock growth. Large variations in producer prices over the cattle cycle, for example, imply that income would vary significantly were the number of animals slaughtered to be held constant. Slaughter does increase in the short term as prices fall and producers disinvest in livestock. Thus, when prices are falling, unless credit is available or there is a good network of roads and transport system to move animals to regions where prices are stable, producers will often sell more animals than they otherwise would to achieve needed income (Jarvis, 1977; Doran *et al*, 1979; Sapelli, 1984). This extends the time needed to rebuild herds and increase output.

Meat and dairy price controls also failed to curb inflation, and in some cases even exacerbated it, in countries where such measures were implemented. The prices fixed were generally too low in relation to demand and supply. Scarcity of products sold at controlled prices rapidly developed alongside parallel markets with prices higher than would in the absence of price controls. As a result the proportion of goods sold at controlled prices fell while parallel market sales increased, with an inflationary effect. These problems were met in several LAC countries in the late 1970s and in SSA in the early 1980s.

These lapses and structural problems such as poor export performance, increasing import bills and huge parastatal financial losses combine to demonstrate the failure of traditional intervention methods. Since the mid 1970s in LAC and Asia and the 1980s in SSA sectoral and macroeconomic reforms have been implemented in several countries. These have emphasized shifts from administered price setting towards greater use of market determined prices, reduction of the statutory roles of public marketing agencies, devolution of some functions to private sector organizations and removal of restrictions on private sector marketing. Macroeconomic reforms involving trade and exchange rate liberalization and reforms of fiscal, monetary and investment credit policies have also been undertaken.

Evidence of the effects of these reforms on the agricultural sector remains tentative and mixed, partly because of the varying degree of commitment to all aspects of reforms. The evidence is still very scanty for the livestock sector. A recent review of the impact of structural adjustment programmes in SSA showed that macroeconomic reforms have spurred external competitiveness while reduced taxation of agriculture has encouraged production and exports (World Bank, 1994b).

One analysis (Valdés 1993) of the effects of economywide and sectoral reforms in Chile and New Zealand showed the overall impact on agricultural production and exports to be beneficial, particularly in Chile, with moderate efficiency gains

in New Zealand. On the debit side, Chile still faces the challenge of raising the incomes and welfare of small farmers in the marginal areas that have benefited least from reform and in New Zealand continuing protection of domestic industry hurts the agricultural sector. The study also highlighted the importance of trade and macroeconomic policies over sectoral interventions, and in particular the strategic role of the real exchange rate in allowing agriculture to compete domestically and internationally.

Another study of the effects of recent dairy price policy reform in Kenya (Steal and Shapiro, 1994) showed that deregulation reduced the negative protection previously experienced by producers by 20-30 per cent. The continuing existence of entry barriers into milk processing for private investors and the monopsony power of Kenya Cooperative Creameries, however, prevented further gains of price deregulation being passed to producers.

What is clear from the scanty evidence is that earlier expectations of rapid economic transformation as a result of reform implementation were too optimistic. Implementation has been more difficult and time consuming than originally expected and in some cases lacked a coherent framework for initiating and sequencing sectoral and macroeconomic reforms. It is also clear that errors in sequencing and adjusting traditional policy instruments to a partially liberalized policy environment could derail or threaten the gains obtainable from reforms.

Special focus on West Africa

West African countries provide a good illustration of the implications of macroeconomic, international trade and sectoral policies for regional trade in livestock products. The Sahel countries, over many centuries, have been the major source of livestock products, mainly fresh meat, to their coastal neighbours. Three major developments in the 1970s and 1980s fundamentally changed patterns of livestock trade in the region. The first was the severe drought of the late 1960s and early 1970s which opened regional markets to substantial extraregional imports of frozen meat, initially from Argentina and later from the EU. The second was the sustained imbalance in macroeconomic policies in the Sahel countries during the 1970s and 1980s, epitomized by the heavily protectionist trading policies in favour of industry, coupled with substantial and explicit taxation of the agricultural sector and the gradual appreciation of the CFA Franc. The third was the emergence of considerable surpluses in the livestock sector of the EU after decades of heavy subsidies.

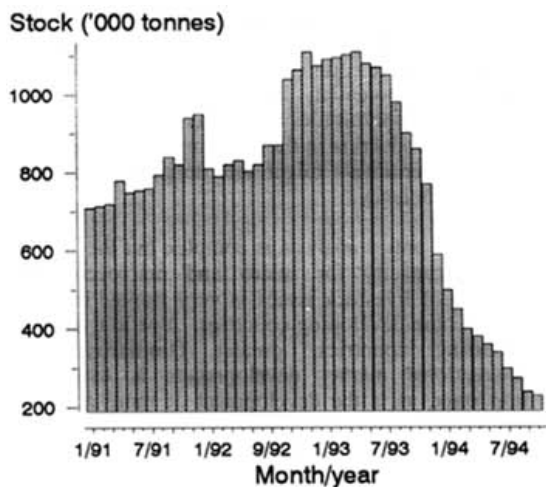
Sahel beef exports to coastal West Africa dropped significantly as a consequence of these developments. In Côte d'Ivoire, for example, beef from the Sahel countries by the end of the 1980s had fallen to half of an initial share of over 60 per cent. Imports of frozen beef from countries outside the region, mainly from the EU, jumped 3-fold from a low of 16 per cent to 44 per cent (Delgado and Lent, 1992). The decline in Sahel exports occurred despite nearly complete recovery in the livestock sector from the drought of the 1970s. This indicates a much greater role of sector-specific and trade policies in the Sahel and neighbouring countries as well as livestock production and export policies in the EU. Underlying the changes in relative export shares was a shift in the price ratio between Sahel beef and imports from 0.5 in the early 1980s to 2.0 by 1990, as import prices for EU beef fell to 20 per cent of their initial level. The fall in the price of imported beef reflects increases in subsidies to exports to West Africa which rose from CFA 124/kg in 1974 to CFA 710/kg in 1991 in order to reduce mounting surplus stocks in the EU. It has been estimated that subsidies to European beef have been as high as 7580 per cent (Delgado and Lent, 1992; Afrique Agriculture, 1993).

In addition to the detrimental effects of EU trade policies on regional exports, the latter have been adversely affected by prevailing policies in the Sahel countries, by trade barriers within West Africa and by economic decline in importing coastal countries.

Domestic factors affecting the supply of livestock exports from the Sahel countries include sectoral policies that discourage trade, mainly transport and marketing policies that raise the cost of operating in local and transborder markets and (to a greater extent) the appreciation of the CFA Franc. Because demand for livestock products is strongly elastic macroeconomic policies in importing countries (through their impact on the overall rate of income growth) have major implications for regional trade in livestock products (Badiane, 1994). The 1980s was characterized by a rapid decline in incomes in most of West Africa and meat demand in the two major importing countries, Côte d'Ivoire and Nigeria, fell from 12.2 and 8.4 kg per caput to 11.0 and 4.2 kg.

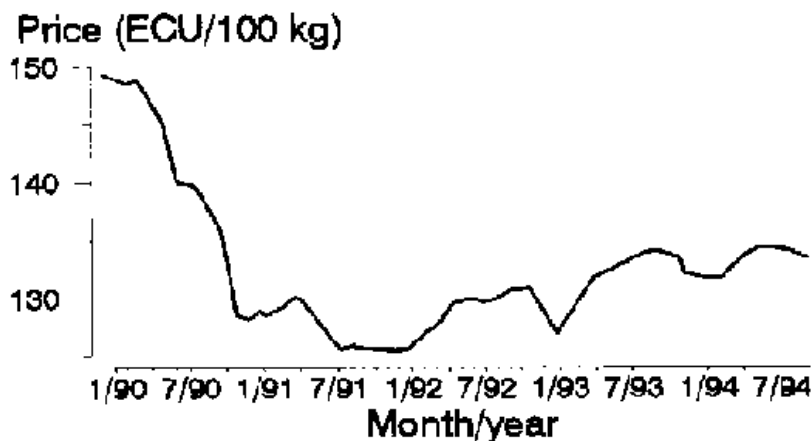
The implications of domestic supply factors in the Sahel countries and of EU export policies for livestock product trade in West Africa have been highlighted by the reaction of regional trade flows to the devaluation of the CFA Franc and the reduction of export subsidies for EU beef. The sharp decline in EU intervention stocks (Figure 5) made it easy for the EU to reduce subsidies on beef exports by as much as one third (Afrique Agriculture, 1994). This coincided with the devaluation of the CFA Franc by 50 per cent in February 1994. EU beef import prices rose by 50 per cent as a result while Sahel export prices dropped in non-CFA coastal countries or changed only slightly in CFA countries. Exports from the Sahel countries reacted favourably and during the first quarter of 1994 exports from Burkina Faso and Niger were three and two times higher than their respective exports for the whole of 1993 (Afrique Agriculture, 1994).

Figure 5 Levels of European Union beef intervention stocks (Source: USDA, 1994)



Exports from the EU are now declining rapidly. These encouraging developments may not last for long because demand and inflation pressures are likely to raise Sahel beef prices while recovery in the agricultural sector of Eastern Europe (which has absorbed the bulk of EU surpluses in recent years), the admission of new members to the EU and the probable persistence of very high EU producer prices despite the recent GATT agreement (Figure 6) could lift EU beef stocks to their previous levels.

Figure 6 European Union beef producer prices, 1990-1994 (Source: USDA, 1994)



The proposed extension of the milk quota system for a further eight years and improvements in feedlot operations are also projected to result in a general rise in EU beef production up to the late 1990s (World Bank, 1993). Higher Sahel beef prices and potential increases in EU beef export subsidies in order to dispose of the higher stocks can be expected to return regional livestock markets in West Africa to the situation of the 1970s and 1980s.

Conclusions

A broad range of policies affects the livestock sector. This range includes macroeconomic, trade and sectoral policies in addition to public infrastructure, animal health services and investment in processing and marketing facilities. Because services such as infrastructure, communications, research, extension and training are public good and are essential to the overall success of other economic reforms government has a role to play in promoting, or actually providing, these services.

Government policy should promote optimal use of domestic resources in the production of livestock as well as other agricultural commodities and products for both domestic consumption and export. Given the diversity of natural, social, institutional and economic resources and the varying potential for livestock sector growth, desirable livestock policies must differ from country to country. Each country's production potential, consumption profile and marketing opportunities will determine the role of livestock production in the economy and the areas in which governments might seek to promote greater market efficiency.

Livestock policy analysis is complex but the institutional capacity for micro and macroeconomic analysis of livestock issues is very limited in most low income developing countries. For low income exporting countries, greater familiarity with international market developments is especially important, as is the development of more accurate and comprehensive data bases for policy analysis.

International market instability and distorted world prices create major policy dilemmas for developing countries that have

the natural resources to produce livestock at a relatively low cost. Should they resist using world prices in situations where these are primarily the result of distortionary policies in developed countries? Should they import lower cost livestock products on the grounds that they benefit consumers despite their negative impact on producers and long term growth? Or should they protect domestic producers to encourage development of their own livestock sectors and thereby forego the benefits of low import prices?

The answer to the first question is clear. Economic theory suggests that international prices are the best measure of opportunity cost and should determine domestic prices. The argument for using world prices does not depend on how they are determined but only on the fact that they are fixed from the point of view of the country concerned. Three reasons can be given, however, as to why international market price distortions might be of legitimate concern to developing countries (Duncan and Jones, 1993). First, if policy reforms in developed countries lead to reduction or elimination of distortions, current prices might not be a good guide for longer term investment decisions. Second, the reduction of domestic production of products that compete with imports might make a country more vulnerable to future increases in world market prices. Third, importing goods at distorted prices will have an income distribution effect, favouring consumers of the subsidized product and harming producers.

Although these arguments might provide a basis for imposing countervailing duty measures to restrict subsidized imports each country needs to make a critical appraisal of its own situation to arrive at a desirable solution. In this connection careful assessment should be made of the possible extent to which inappropriate domestic macroeconomic, trade and other policies are also important factors in the unsatisfactory performance and contribution to overall economic growth and poverty alleviation of the agricultural sector in general and the livestock subsector in particular.

The processed food sector in developing countries offers additional opportunities for growth of the livestock sector. This is true for the Latin American and Asian countries already heavily involved in the export trade. In the medium term, however, low income countries in the Sahel and other less developed regions might also be able to increase production of dairy and other processed livestock products to meet expanding regional and local demands. Beyond regional markets, formidable barriers to entry remain in the markets of the developed countries. To overcome the obstacles in these markets developing countries need to engage in more frequent negotiations with the major industrial countries for better market access and to seek agreement to be consulted in the setting of food import standards. Developing countries also need to encourage foreign investment in their domestic food industries in order to get the support of the multinational firms that dominate the food markets in developed countries.

In all regions, but most especially in sub-Saharan Africa, governments have a role to play in ensuring the availability of the infrastructure and support services that producers need in order to be able to respond effectively to price incentives. In addition, governments need to help develop private sector capacity where state marketing boards are -being dismantled and the private sector shows signs of not being able to respond to the new marketing environment.

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Appendix A. Developing countries by geographical region

Region	Countries
Sub-Saharan Africa	Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central Africa Republic, Chad, Comoros, Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Saõ Tome and Principe, Senegal, Sierra Leone, Somalia, Swaziland, Sudan, Tanzania, Togo, Uganda, Zaire, Zambia, Zimbabwe
Asia	Bangladesh, Bhutan, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Korea Democratic People's Republic, Korea Republic, Laos, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Vanuatu, Viet Nam
West Asia and North Africa	Afghanistan, Algeria, Bahrain, Cyprus, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, United Arab Emirates, Yemen Arab Republic, Yemen Democratic Republic
Latin America and Caribbean	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, French Guiana, Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Mexico, Netherlands Antilles, Nicaragua, Panama, Paraguay, Peru, St Kitts-Nevis, St Lucia, St Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela

Research and technology transfer for livestock development

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Introduction

Developing countries have nearly two thirds of the world's livestock but produce only about a quarter to a third of the world's meat and a fifth of its milk. Low output in the developing regions is due to both low offtake rates and low yields per animal. Beef and veal output per head of cattle in North America is 281 kg whereas yields in Africa and Asia are about half at 142 kg and 129 kg. In South America, the developing region where livestock production is most advanced, beef and veal output per animal is 213 kg. Milk yields are almost ten times lower in Africa and four times lower in South America and Asia than in North America and Europe (USDA, 1990; FAO, 1992a; 1992b; 1992c; World Bank, 1993). Relatively few cows are milked in Asia but the market is growing quickly. These figures suggest that major improvements in livestock productivity are possible. Research can provide technologies to help achieve productivity increases but technology needs to be transferred to producers to ensure impact.

Global research and development is expanding to include not only international, national, regional and developed country research institutions but also development and donor agencies (including NGOs) and developing country governments. These developments can be seen as problems or opportunities. They are opportunities if this group of expanding partners and stakeholders develops closer links and new functional models. New modes of functioning can help to link the interests and activities of all concerned in development. The mandate of the International Livestock Research Institute (ILRI) is also being broadened at a time when the growth rate of available resources may be slower than in the past. Making an impact in a global context with so many partners and stakeholders will require more focus and closer cooperation and coordination.

A framework for international action to support livestock development is thus timely. The goal of this framework is to help achieve increased and sustainable food production and generate more income for improved food security in low income countries. This goal fits within the new global mandate of ILRI which, although its main function is research, cannot ignore the need to link its research to technology transfer efforts if it is to make an impact.

This paper considers issues related to the role livestock research can play in strategies making up this framework for action and especially its effective linkage with technology transfer. The focus is on Africa because the region, while not being unique in facing the problems of the developing world, provides the greatest challenge to the global agricultural development community.

The current state of research

Development of an effective framework for action needs to take into account the current state of research in the global system and particularly in developing nation programmes (*Sanders et al*, 1995). Prevailing research and national policy need to be considered. The neglect of agriculture, and especially of research, since independence in Africa defines the current state of national research programmes. The great need of national programmes in Africa remains human capacity and institution building.

From the time of the Green Revolution successes in the late 1960s to the early 1980s the international and developed country donors operated on the paradigm that introduction of agricultural technology was the engine of growth. This was not only for agriculture but also for the whole economy in most lower income developing countries. The global research system has consisted until recently mainly of the National Agricultural Research Systems (NARS) and the International Agricultural Research Centres (IARCs) sponsored primarily by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR grew out of the Green Revolution successes and has provided the predominant institutional model. Following the success of the Green Revolution, the response of the international donor community was to expand the IARC system. The IARC model has been that agricultural research requires narrow definition of priorities, well trained multidisciplinary teams of scientists and long term commitment (Ruttan, 1982). Developed country donors have attempted to isolate the IARCs from short run political and economic pressures and provided sufficient financial incentives and infrastructure to create and motivate multidisciplinary teams of scientists over long periods covering 10-20 years.

Donor support was also provided to NARS, the IARC model being adopted by most of these. Human capital formation in the NARS has now been supported by both the developed countries and the IARCs for over 20 years. NARS have been unable, however, to remain isolated from local political and economic pressures and to maintain size and continuity in their research programmes. As agencies of their governments NARS have had to respond to the continually changing objectives of their governments and, often, of donors. Thus, despite the progress made the NARS still need to improve human capital and institutional capacity.

The current state of research in Africa is also in part a function of the nature and focus of the institutions set up during the colonial period and the technical assistance model that has dominated since independence. A skeletal agricultural research infrastructure was established in most countries of sub-Saharan Africa early in the 20th century (McElvey, 1965). Research concentrated almost exclusively, however, on export crops such as oil palm, cocoa, coffee, groundnuts and cotton which yielded rather substantial returns. Little attention was given to research on food crops and, essentially, hybrid maize in Kenya and Zimbabwe was the only staple food receiving substantial research effort during the colonial period. After independence the institutional base of agriculture was largely geared to supporting large farms, plantations, ranches and export agriculture (Eicher, 1993).

African governments have mainly been concerned until recently with highly visible development projects. They have considered the agricultural sector to be a labour pool for industry and a source of cheap food for urban areas. Policy makers have overlooked the potential returns from investing in agricultural research. In economic terms the rate of time discount was too high. Agricultural research, especially increasing the institutional and human capital capacities of research institutions, is a long term investment. It has very high payoffs but most returns are subtle and not immediately obvious to policy makers. Diffusion of new technology is usually gradual and food price declines are small. With the historic major disincentives against the agricultural sector in most sub-Saharan countries, there should be even greater appreciation of the gains from new technologies that have been achieved.

The livestock research policy environment

Research policy is mainly translated into investment in agricultural research capacity. Where investment has been inadequate, such as in Africa, there has been a marked lack of success in development and transfer of new technologies. Slow development due to lack of support for human capacity and institution building by governments has been compounded by donor insistence on using expatriate technical assistance to support national research programmes (Eicher, 1990).

Life became more difficult in the global research system during the 1980s when there was a shift in the predominant paradigm in development to "getting the prices right". This implied structural adjustment, accompanied by devaluation, changes in emphasis from parastatals to development of a private sector and a stress on exports rather than achieving food self sufficiency. The forced economic changes of

structural adjustment and extraction of capital to repay the loans of the 1970s made the 1980s and the first half of the 1990s very difficult for most developing countries, especially the low income countries. Many changes resulting from structural adjustment will help the agricultural sector in the long run. With the shift of the development paradigm, however, there has been a levelling off of donor funding for international agricultural research. Competition for donor funds then became more intense and acrimonious in the 1980s and 1990s due to efforts by both IARCs and NARS to sustain research budgets.

The scientific gap and institutional immaturity in Africa is also in part the result of lack of investment in developing scientific and managerial capacity (Eicher, 1990). Following 30 or more years of independence, Africa has the lowest scientific capacity of the developing regions. It has only one fifth the number of research and development scientists and engineers per million compared to Asia. About a quarter of the total value of human resources in NARS, including academic staff, are expatriates (Eicher, 1990). About 20 per cent of researchers in sub-Saharan Africa are engaged in research related to livestock production compared to 17 per cent in Asia and the Pacific (excluding China), 21 per cent in LAC, 16 per cent in WANA and 18 per cent for the developing world in general (TAC, 1993). Africa, however, has far fewer scientists than other developing regions.

To function effectively NARS need not only trained personnel but also adequate funds to cover fixed and operating costs. Government funding for NARS in Africa has rarely been sufficient and has often been used ineffectively. Average expenditure on agricultural research for the less developed countries, including SSA, in 1981-1985 was 0.94 per cent of agricultural GDP (Pardey *et al*, 1991 cited by Eponou, 1993). Other sources put the figure at 0.54 per cent of agricultural GDP and state that this is only about a quarter of the percentage investment in developed countries (Jain, 1990). National resources are now mainly used for maintaining staff salaries, which often account for 90 per cent of the total budget, and infrastructure. Donor funding is thus used most often for the marginal costs of experiments. Many NARS are still considered to be performing badly in spite of donor aid.

The human capacity/institution building model must replace long term technical assistance in order to develop national research capacity. Building effective national systems capable of doing adaptive, as well as applied, research will require continued investments in human capacity through higher education in the agricultural sciences. IARCs can play an important role in NARS capacity building through training and collaborative research. Short term training courses should be supported by research training to collaborators in the context of projects undertaken in CGIAR-sponsored cross-centre and ecoregional initiatives. CGIAR scientists can also act as technical resource persons in applied and adaptive research projects that build upon results and technologies developed by the CGIAR. Increased efficiency will result from regional groupings of NARS or using established networks to carry out this research.

It is, however, questionable whether the necessary human and institutional development can take place in a research environment increasingly dominated by short term project related research funding. Short term funding is a particular problem for livestock research since the reproduction cycle of animals is so long. Many technological advances in the continent, such as the development of Zimbabwe hybrid maize, have their roots in research studies undertaken by a small group of scientists working over several decades (Delgado and Mellor, 1984). Human capacity/institution building strategies and long term funding for livestock research projects would be worthwhile components of any framework for action.

Sectoral and macro policy effects on livestock research impact

The environment affecting research is determined not only directly by research policy but also by sectoral and macro policies. These policies can have a direct bearing on the demand for technological change and the extent of adoption and thus the impact of research efforts. Some such policies can depress domestic production and encourage poor management of the natural resource base. These include: food pricing policies that subsidize consumers and tax producers; overvalued exchange rates that favour imports rather than domestic production; and inefficient input and credit market policies that inhibit the uptake of new technology (Ehui and Lipner, 1993).

Sound sectoral policies in support of animal agriculture can have several effects on producers. They provide incentives to intensify livestock production with purchased inputs and to commercialize livestock activities and integrate them in the market economy. They also encourage investment in items such as barns and fencing, encourage public investment in infrastructure to improve market efficiency, provide regulations that facilitate market operations for the supply of inputs and the delivery of animal health

services and assist in providing improved credit facilities (Fitzhugh *et al*, 1992).

Macro policies can affect research impact through their influence on food production, distribution and consumption. Until recently trade policies encouraged imports of cheap dairy products into Africa and discouraged development of domestic dairy industries (von Massow, 1989). Policy changes on the part of the EU, the USA and other major dairy exporters under the GATT agreement have led to a decline in world milk supplies, pushing up world market prices and making African domestic production more competitive with imports from developed, especially European, countries. Even if world market prices do not continue to rise as expected (Shapiro *et al*, 1990; Shapouri and Rosen, 1992) domestic milk production in many sub-Saharan countries will remain competitive due to recent currency devaluations (Walshe *et al*, 1991). Livestock production in the semiarid areas of West, East and Southern Africa also has a comparative advantage relative to livestock production in coastal humid countries that improves the prospects for interregional trade.

Policy reforms such as structural adjustment need to go beyond liberalizing output and input prices. A recent analysis of effects of price and macro policies on livestock production shows that, since the early 1980s, there has been a reduction in price discrimination against producers in sub-Saharan Africa. There is still scope, however, for improving price incentives if macroeconomic imbalances that cause exchange rate distortions and high domestic inflation are corrected (Williams, 1993). An analysis of the effects of policies on periurban dairying near Nairobi looked at institutional factors beyond prices that needed policy reform. Producers were found to have major opportunities for higher profits since market access is good and productive technology can be profitably used (Steal and Shapiro, 1994). An analysis of dairy price decontrol indicated, however that the market remained non-competitive. The effect on producer incentives is thus still negative compared with potential profitability in a policy free environment.

Policy research and information dissemination may need to be a part of the strategies making up the framework for action. Such efforts will need to improve the data base on livestock, as well as its accessibility to NARS and regional research institutes (RRIs). The framework for action should also improve the ability of NARS to provide analyses to help policy makers in developing countries anticipate and understand the probable consequences of policy actions. Policy research and analysis of this type is needed because new livestock policy instruments such as full cost pricing for input services, payment of full market prices and interest rates are being introduced in many developing countries. There is a need to know whether these policies facilitate or hamper livestock development, including the sustainable use of the natural resource base.

Making the case for livestock research

Livestock research objectives have a direct bearing on the strategies chosen and the ways that research is organized to achieve them. The chosen objectives also affect the ability to obtain the needed resources. Research objectives derive from policy decisions made by partners and stake holders in development -NARS, RRIs, research networks, developed country research institutes, IARCs, NGOs and developing country governments and donors. Objectives should ideally reflect the goals and aspirations of the direct beneficiaries in addition to consideration of the interests of society as a whole. Stakeholders in developing countries, including farmers, extension agents, agribusiness and policy makers, must be involved in setting research and development priorities. Involvement is essential to ensure that research is relevant to the needs of the targets.

It is increasingly recognized that even local decisions can affect the whole world. In a world growing ever smaller and more closely interconnected the global interests of the developed world are not only becoming broader but also more powerfully enunciated. International concerns about livestock development are exerting a strong influence on research policy and affecting donor attitudes to funding of livestock activities. These concerns include: the environment; human health; animal rights; equity issues, including poverty and gender; the use of existing food surpluses from the developed world; and private versus public sector involvement in agricultural development. The concerns and interests of donors and interest groups must be carefully considered and efforts made to educate the general public. Education of the public and policy makers in the developed countries would be a worthwhile component of the framework for action.

The case of environmental concerns is particularly instructive. Too often, and mistakenly, development of animal agriculture is seen as harmful to the environment. Global losses of tropical rainforest are a major international concern and deforestation has been associated with increased production of greenhouse

gases and global warming. Another global concern is desertification. That livestock are a major factor in deforestation and desertification has become a widespread controversy in the developed world and affects donor contributions to research and development. Empirical evidence does not support the contention that livestock necessarily contribute to these problems. In the humid and subhumid zones the major impetus for expansion of agricultural land is population growth combined with shifting cultivation (NRC, 1993).

Work on the dynamics of Sahel ranges shows that livestock are not a major factor in degradation. Even under the extreme grazing pressure that occurs during drought less palatable and lower productivity plants supplant more palatable, more productive species only in the short run. The more productive species are then able to re-establish themselves earlier than they might have if they had been subject to continuous grazing pressure (Hiernaux, 1994). A recent review of literature on the impact of livestock on rangelands (Dodd, 1991) concluded that effects of grazing and drought had been confused and that there was no solid evidence of irreversible effects on vegetation from livestock except around water points and permanent human settlements.

Other recent research shows that it is mainly poverty that drives farmers to exploitative resource-depleting practices (Vosti *et al*, 1991). Raising farm incomes by cash generating activities such as livestock can lead to a withdrawal from marginal areas that are susceptible to degradation. Neither people nor policy makers in poor countries will feel concern for the environment or biological diversity, however until a higher proportion of the population is able to satisfy its basic needs and the economic system develops its capacity to respond to the rapidly increasing demands for food products. The immediate problem, therefore, is to get intensive technologies moving through NARS research systems and onto farmers' fields. Developing country policy makers will then have the flexibility to respond to environmental concerns (Sanders *et al*, 1995).

More research and policy attention should certainly be devoted to the environmental concerns of the global community. These issues should not, however, be barriers to funding livestock research and efforts to introduce new livestock technologies since such introductions can help resolve these problems. The low income developing countries need to accelerate the pace of food output increases.

Research strategies to promote livestock development goals

Until recently the IARCs had global or continental objectives for specific commodities. The NARS role was seen as selecting and adapting what was most useful for their own environments from IARC results and to do agronomic and production systems research specific to their regions (Lynam and Blackie, 1994). NARS have taken over more of the breeding functions as they have developed and have fought for a larger share of international resources as these have become scarcer. RRI's are also coming into being to achieve critical mass and to attempt to solve problems common to more than one developing country. This is causing the IARCs to redefine their roles and seek to move upstream in the technology development process. At the same time the IARCs must ensure that their work results in impact. To accomplish this there is a need for greater cooperation and closer collaboration between IARCs and NARS so that more impact is achieved with available resources.

Among modes of functioning that are emerging to meet global agenda needs are research programmes headed by the CGIAR. Cross-centre programmes are being called for by TAC and ILRI has been charged with taking the lead in livestock research in the CGIAR system. ILRI will thus have a major role in the livestock components of many CGIAR projects. It will also take the lead in CGIAR systemwide livestock programmes and collaborate with sister institutions concerned with livestock research including CIAT, ICARDA and IFPRI. A challenge facing ILRI and the CGIAR is effective integration of NARS in ecoregional and global initiatives to help them develop their human and institutional capacities.

In these new modes the comparative advantage of the various partners in research needs to be taken into consideration in defining their respective roles. Research can be categorized as basic/strategic, applied or adaptive (Figure 1). These categories form a continuum in the research spectrum and all have implications for development. Basic/strategic research is scientific investigation that advances the knowledge of feasible biological processes but may not have immediate application in farming practices. In basic/strategic research the problem definition is more general, the degree of predictability of results is moderate and the extent and time of impact are broad and long. Applied research is oriented towards achieving a practical objective, such as developing the genetic resistance of animals to parasites. Adaptive research refers to adjustment of technology to a particular set of farming conditions, an

example being the selection of certain forage species for use as feed in a specific agroecological zone or region. Problem definition in adaptive research is very specific, the predictability of results is very high and the extent and time of impact are narrow and short.

In the global system, NARS and RRI's have a comparative advantage in adaptive and applied research whereas the IARCs and advanced institutes have advantage in basic/strategic and applied research. Basic research requires expensive equipment and staff skills that few developing countries possess. The IARCs represent, however, only about 3.5 per cent of the global agricultural research expenditure of US \$ 9 billion (Eicher, 1993). IARCs are well positioned to assist NARS and RRI's with transfer of basic research results from specialized institutes in developed countries. IARCs and RRI's have comparative advantage for doing research from which results "spill over" to similar agroecological and socio-economic conditions across national boundaries.

One challenge of the framework for action will be to define strategies to increase cooperation with institutes in donor countries. Some of these already contribute to development of the livestock sector in developing countries. There is, however, a need to increase collaboration with universities in North America, Europe and Asia. Involvement of these institutions in the new modes of undertaking research will influence the policies of their governments with regard to research in developing countries and will help determine the extent of support provided.

Figure 1 Characteristics of types of research and comparative advantage of research institutes that make up the global research system

Characteristics	Types of research		
	Adaptive	Applied	Strategic
Definition of problem	Specific	Specific	General
Predictability of results	High	Moderate	Moderate
Likelihood of achieving impact	High	Moderate	Low-High
Applicability for impact	Narrow	Moderate	Broad
Time to impact	Short	Intermediate	Long
Research institutes	Comparative advantage		
	Adaptive	Applied	Strategic
NARS	+++	++	+
RRI's	++	+++	+
IARCs	+	++	+++
Advanced institutes	n.a.	++	+++

Effective collaboration with RRI's offers opportunities to accomplish more with the scarce resources available. Several regional organizations have been formed in Africa in attempts to use resources more efficiently while tackling problems of a regional nature. The Centre International de Recherches et Développement sur l'Élevage en Zone Sub-humide (CIRDES, formerly Centre de Recherches sur les Trypanosomes Animales - CRTA) in Burkina Faso and the International Trypanotolerance Centre (ITC) in The Gambia are attempting to serve broader regional mandates. Regional programmes can complement the functions of NARS and IARCs and serve as mechanisms for NARS to pool resources and rationalize responsibilities in the accomplishment of individual and collective objectives. Like NARS, however, they frequently lack sufficient funds.

Networks are another mechanism for cooperation and are maturing rapidly as an effective means of allocating resources. Networking allows collaborating NARS partners to pool and coordinate scientific efforts, do more effective research on problems of mutual interest and avoid inefficient multiplication of effort. National scientists are increasingly well trained but there are few in the same discipline in one institute or even in one country. Multilocational projects managed through networks provide opportunities for enhancing research efficiency and allow the introduction of standardized methodologies that lead to more significant conclusions than can be obtained from isolated experiments.

IARCs already play a major role in networks as partners in collaborative research, providing training opportunities to network participants, disseminating research methods and results and facilitating the exchange of information. IARCs also assist with network support functions which include helping to

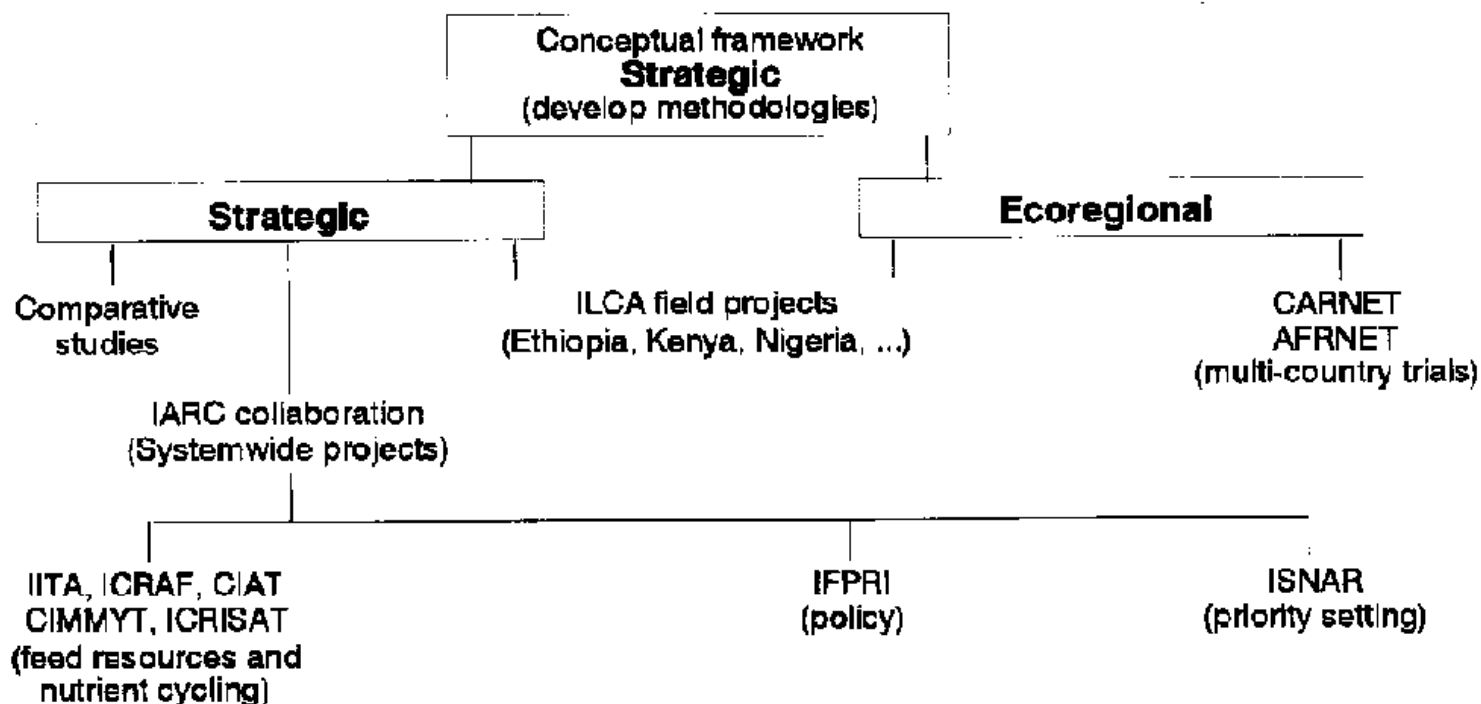
attract donor funding, organization of meetings for setting up network steering committees, sponsoring meetings of participating scientists and providing services in areas such as data analysis, documentation and publishing. A challenge for ILRI to be included in the framework for action will be how to maintain and expand its networks to include the new NARS partners of the global mandate.

The organization of dairy research programmes within the conceptual framework developed by ILRI provides an example of how partners in research can work together to increase impact. The conceptual framework is a research management tool that ensures:

- coherence between strategic, applied, and adaptive research objectives and across disciplines;
- research at any level is done in a systematic manner;
- organization of multidisciplinary research;
- there is no duplication of research across sites; and
- consistency of research methods and resulting data across sites to increase relevance and impact.

Use of the conceptual framework (Figure 2) allows involvement of many partners, enables them to coordinate efforts at all research levels and encompasses both systemwide and ecoregional endeavours. Support for these activities in the framework for action would ensure that there are sufficient resources to realize the potential impact.

Figure 2 Organization of dairy research projects under the conceptual framework



Linking research and technology transfer

As the number of partners and stakeholders expands the effective linkage of livestock research and technology transfer is becoming more complicated. Greater coordination and synergy between research and technology development will also be required if technologies are to be transferred and impact achieved. The expanding global research system will need greater interaction with development agencies, including multilateral organizations such as FAO and UNDP, trilateral government agencies and NGOs. Developing country governments will also have an increasingly greater say in the research and development activities that take place within their borders. The framework for action must thus tackle the effective linkage of technology transfer with research.

Among other international organizations, FAO confronts livestock development across a broad spectrum.

It provides technical advice and assistance to the agricultural community, governments and funding agencies. It collects, analyses and distributes information, advises governments on policy and planning and provides opportunities for governments to meet and discuss food and agriculture problems collectively. FAO is taking the lead in organizing work on the conservation and utilization of animal genetic resources in which ILRI plays a major role. Partnerships of this kind can provide essential critical mass and state of the art technology and knowledge for the benefit of national research institutes.

NGOs can also play an important role in transferring livestock technologies in developing countries. They have close contact with producers and their potential to expand delivery of technical services to producers and to participate in field testing activities is high. Many donors are increasingly channelling development support through NGOs.

Examples of new modes of functioning in this area include the "FAO/IARC Collaboration for Technology Transfer" projects organized by FAO in collaboration with CGIAR centres. These projects are to promote proven IARC technologies that are awaiting diffusion. Included are NARS and extension experts from countries in a region (or ecoregion) where conditions conducive to the adoption of the technologies prevail. In the first phase, a workshop is held to present the technologies and to prepare country project proposals that can be part of a regional proposal to be submitted to donors. In the second phase the country projects are carried out with technical assistance from FAO experts with the IARC scientists who developed the technologies acting as resource persons. An important innovation of these projects is the role of information sharing between regions. In the FAO/ILRI project on cow traction the second phase projects are initially to be carried out in Eastern and Southern Africa but Asian traction experts will participate in the first phase workshop to share their expertise and experience and to explore the possibilities of extending the project to Asia.

Where the needed resources will come from

African governments will need to improve their support for agricultural research and extension institutions. They will also need to become more efficient in the use of their own funds. Reliance on donor funding for critical investments is increasingly risky because donors often have short time horizons and make quick changes in priorities and funding. This is incompatible with institutional research development requiring long term investment. The key issues in Africa are whether and where governments can find resources to support agricultural research.

Structural adjustment is making agriculture more profitable. African governments are increasing their revenues through these programmes by tax reform and by selling public enterprises that they had to subsidize in the past. They are also cutting food subsidies to urban consumers. Since agricultural research is a public good with a very high return on investment - even though it takes a long time to realize - more revenues should be invested in it as they become available.

As economies in the developing countries improve they need to play a greater role in funding research but developed country contributions will clearly be required for some time. This need not be seen solely as a philanthropic or humanitarian activity as funding research in developing countries can benefit agriculture in developed countries. Far more genetic diversity exists in plants and animals in Africa than in the developed countries. This is true, for example, of resistance to endoparasites in some African sheep and goat breeds. Embryo transfer has allowed five African goat and sheep breeds to be introduced to Australia where they will be reared for live (re)export. This was not possible before due to the disease considerations that have been a constraint to export of live animals from Africa. The transfer of this technology was possible due to the public good nature of research generated technologies.

There is current debate in the donor countries on whether the private or the public sector should finance the development of agriculture in developing countries. Its origin lies in concerns for liberalization and privatization arising from the process of structural adjustment being undertaken in the developing world and it is gaining in importance with the conclusion of the GATT negotiations. The belief is that in many countries the economic situation can only improve if the public sector disengages from economic activity. This argument neglects, however, the role that government can play to correct for market failures arising from the existence of public goods (Smith and Thomson, 1991).

An example is the significant role that research can play in economic development. There is now broad consensus that a large proportion of agricultural research must be recorded as a public good and requires funding by the public sector even in countries pursuing free market philosophies. The reasons

for this (Ellis, 1992) are:

- most agricultural innovations (including, for example, cultivation practices and disease resistant animal breeds) are in the public domain after release and cannot be protected by patents or copyright laws;
- private enterprise usually restricts itself to applied research that lends itself to copyright protection but this is a small fraction of the research needed to achieve the long run output, equity and food security goals of society;
- small holders, who are often the main beneficiaries from research in developing countries, cannot easily organize and finance the scale of research required for widespread advances in technology; and
- consumers, who are the other main category of research beneficiaries, would not organize and finance agricultural research of their own volition.

It has been said that "The only meaningful approach to modern agricultural research is to conceptualize most of its contribution as public goods. As such they must be paid for on public account, which does not exclude private gifts to be used to produce public goods." (Schultz, 1984). Public investment in livestock research can also be very profitable judged by the high rates of return to research of greater than 50 per cent obtained in other parts of the world (Pinstrup-Andersen, 1982).

Conclusions and recommendations for the framework for action

Major improvements in livestock productivity are possible and needed to assist economic growth in developing countries. Research can provide technologies to help achieve productivity increases but transfer of technology is needed to achieve impact. The global research and development community is expanding and new functional modes are required to ensure coordination of the use of resources. This paper considers issues related to the role of research in the strategies making up an action framework to promote livestock development and especially effective linkage of research with technology transfer.

The action framework will need to include strategies for research and technology transfer policies especially in the developing countries. It will also need measures to promote an increase in agricultural research investment within the framework of a human capacity and institution building model to replace the technical model that has been dominant in the past. The effects of macro and sectoral policies affecting research impact also need to be considered as do international concerns about the consequences of livestock development on the environment, human health, equity and other critical issues.

An effective mix of the various types of research and the strengths of all the partners in the global research and development system need to be included in the strategies chosen to promote livestock development goals. Models such as CGIAR ecoregional projects, the CGIAR systemwide livestock initiative and the ILRI conceptual framework for dairy research provide useful examples. Organizational models that ensure the transfer of research generated technologies also need to be designed and must include the role of international organizations and NGOs. FAO/IARC cooperation provides a useful model for the effective linkage of research and technology transfer.

To accomplish the framework's objectives explicit measures will be required to harness resources and ensure impact. Such activities could include:

- an ILRI/FAO/IFPRI policy unit charged with carrying out impact and policy analysis, educating the public, and garnering advocacy and support for livestock development; and
- a livestock policy network such as that seen as part of the ILRI/IFPRI project on the determinants of dairy demand, which could help train NARS scientists in policy research and analysis and could be tied to the previously described policy unit.

Using these two structures, a "2020 Vision for Livestock Development" could be mounted to promote the message of the positive effects of livestock development for the public, interest groups and donors in the developed countries. These tangible measures would ensure that the framework for action is translated into reality and result in livestock development that will have a strong impact on human well being in low

income countries.

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Discussion sessions: Part Two

[Macroeconomic international trade and sectoral policies in livestock development](#)
[Research and technology transfer for livestock development](#)

Macroeconomic, international trade and sectoral policies in livestock development

Discussion summary

There was animated discussion on this paper and more detailed explanations were called for in some aspects. It was emphasized that the analysis in the paper does not support active government intervention to limit trade in order to further existing or new development policies. It was also pointed out that livestock sectors have suffered from policy interventions due to the anti-agriculture bias displayed by the economywide and sector policies adopted in most developing countries.

In addition to the range of policies that now affects the livestock sector there is a more fundamental question. It concerns the very roots of livestock policy formulation within countries. There is a need to know how the process of policy formulation is initiated and the circumstances that contribute to this process. What makes a country overemphasize the use of resources (for example for dairy development) as opposed to a more balanced development of the totality of the sector also needs to be known. There is now a new approach to more integrated use of natural resources that will require policy support for systems oriented work. This side of policy may be worth addressing to provide a framework for more interventions (Devendra). The analysis in the paper does not support active government intervention to limit trade in order to further existing or new development objectives. With regard to the issue of better understanding policy formation the political economy of trade policies should be recognized more widely, particularly with regard to the ability of highly concentrated interest groups (whether consumers or producers) to lobby policy makers effectively to enact trade control measures that do not necessarily benefit the nation as a whole (DeRosa).

There may never be any justification for imposing mechanisms that restrict imports, either by tariffs or quantitative restrictions, to protect an infant industry and particularly if any revenue generated is used to develop the domestic industry (Mack). There is little support for infant industry protection in economic theory and in practice there are no examples of such schemes having succeeded (DeRosa).

There is real need for in-depth studies into livestock development as affected by international trade requirements, including GATT. Small dairies in developing countries are going to be seriously affected if import of powdered milk is allowed. Policy measures such as quotas or taxation can be used but if the price of recombined milk is cheaper than dairy farmers will be destroyed. Developing countries such as Thailand are expected to benefit from export of rice but there may be little benefit if its dairy farms are going out of business (Chantalakhana). The presentation may have given the impression of advocating international policies for the livestock sector possibly due to the discussion of the West African question where regional markets were subject to heavy export dumping of livestock products by the EU. Careful

reading, however, shows that the main argument is that the livestock sector has suffered from policy intervention due to the anti-agriculture bias displayed by the economywide and sector policies adopted in most developing countries. The call for measures to protect domestic sectors from the effect of dumping is not international in the sense of wanting to provide undue protection to this sector. It is, rather, rightfully recognized that the input price of EU livestock products is by no means a long term indicator of border prices facing West African producers since it is mainly dictated by EU stocks which not only fluctuate but are also very unlikely to be sustained in the long run. The short run welfare cost of allowing these imports at their dumped prices are therefore likely to be much lower than the welfare loss in terms of lost production potential in the long term given the comparative advantage many West African countries enjoy in livestock production (Badiane).

In examining the recommendations that arise from theoretical models it is important to remember that policy changes affect people. Equity considerations can be as important in practice as efficiency considerations. Political considerations are also important in liberalizing economies - those who lose from a policy change "vote" (Young). The political influence of social, economic and other groups adversely affected by trade and policy measures is not always proportional to their numbers. Repression of agriculture in lower income countries is frequently a reflection of the limited political power of rural communities to match the more effective political influence of highly concentrated industrial and urban interests in maintaining import substitution policies and low food prices. Achieving trade liberalization to reduce bias against agriculture and increase national output and welfare is particularly difficult and might not be accomplished entirely through sentiments expressed in ballot boxes (DeRosa).

Research and technology transfer for livestock development

Discussion summary

There was concern from some part of the group that direct participation by the beneficiaries - the small farmers - had not been accorded sufficient attention but this argument was countered by the fact that the social dimension is included to the extent that what is recommended will positively affect the welfare of the farmer. There was avid discussion on the role of research and how it should be funded: consensus was difficult to reach on the latter mainly because of efficiency issues - the public impression was that staff numbers and therefore expenditure had increased relative to operations but it was then agreed that this should be viewed in the light of the initial low starting point of staff numbers and salaries. Finally the role and methods of technology transfer were discussed especially in relation to the framework for the policy unit proposed in the paper.

Participation by beneficiaries

The policy research programme presented seems to lack a social dimension and is focused more on increasing productivity by policy related means rather than by rural development *per se*. The proposal for the livestock policy unit does not show clearly how the main actor, the farmer, will be involved (Lahlou-Kassi). The paper is about research policy and the impact of macro and sectorial policies on research funding and the extent of adoption of research results. The social dimension is included to the extent that what is recommended will positively affect the welfare of the farmer. Integrated rural development is certainly the overall goal but livestock are here treated as a component of the development strategy. Increased livestock productivity will contribute to improvements in rural development but "rural development" is too broad a context here. Effective research and technology transfer show concern for the farmer as the overall goal (Ehui).

An important issue in livestock research is project formulation that has specific focus, is

concerned with real needs and involves the participation of farmers in all aspects of problem definition and implementation. In this sense, the systems approach provides the most important means for project formulation and can be carried all the way through to monitoring, evaluation and impact (Devendra).

Research funding and efficiency

It may not be very useful to keep asking for more money for research: what is needed is greater efficiency. The example of increase in funding versus staff growth rate is instructive. In the period 1961-1965 to 1981-1995 agricultural research support grew at an annual rate of five per cent from US \$ 149.5 million to US \$ 372.3 million. During the same period for the same institutions staff numbers increased by 7.2 per cent annually from 1323 to 4941 and in fact staff expenditure grew twice as fast as operation expenditure (de Haan). It is true that NARS will need to be more efficient in managing their resources but the fact that resources currently allocated to research and extension are very limited should not be ignored (Ehui).

The reasons for the insufficient financial support to livestock research need to be investigated. Reference can be made to the ISNAR study on OFROR country experiences which indicates the importance of measuring impact, attaining efficient technology transfer and adoption and of bringing successes to the attention of public and politicians (Peters).

There should still be scope, and there are certainly reasons, for higher efficiency. The tremendous contribution of agricultural research both at national and international levels over the last 20-30 years should not, however, be ignored. There is no part of the globe where agricultural output has not grown considerably and yields have increased in many regions. This clearly would not have been possible without research. This does not change the fact that impact remains difficult to document. There therefore does not seem to be a need to be apologetic about asking for more resources. The rising challenge in SSA and Southeast Asia with respect to poverty alleviation, malnutrition and population increase leaves no other choice than to increase support to research. This is particularly so given the recent trends of declining support which can mainly be linked to aid fatigue rather than to a lack of performance among research systems. With this background it appears dangerous to stress the high labour expenditure shares in research institutions. Research is a service oriented business and therefore quite labour intensive. Stressing the shares instead of looking at the aggregate level is misleading. Support for agricultural research in absolute terms is very low. In the same way high growth rates in research expenditure are valuable only when the absolute level and especially the very low base figures are taken into consideration (Badiane).

There is a clear need to increase the efficiency of research resource use in developing countries. Research is fragmented across subsectors/commodities and disciplines and there is limited coordination or interdisciplinary collaboration. The need is to increase support to existing staff through training and better equipment in order to raise effectiveness. National programmes in Africa should take advantage of linkages to regional organizations which support agricultural research and capacity building, such as SPAAR, SADCC, ASARECA and CILSS. There are congruence tests between research expenditure and commodity values which can help assess the comparative validity of resource allocations to research for example, on cereals, export crops and livestock. More attention to impact evaluation could help justify more funds. The need to pay more attention to environmental and social issues presents new challenges that neither national nor international research systems are yet equipped to meet (Oram).

Technology transfer

The process of programming research is important in collaborative efforts with NARS. Extension institutions should provide the link to the users of technology. Extension methods

applied in NARS research and development systems can be a constraint. ILRI needs to consider how it relates to these processes and method oriented issues. Research and extension activities to develop and transfer technology may have to be directed to items which could become private goods, such as AI and seeds. Organizational and institutional issues may need to be scrutinized in terms of speeding up development; impact and sustainable development at system and sector levels (Peters).

There is a case for large scale management experiments and learning by doing. It has been advocated - although for trees, fish, water and corporate owners and not small poor farmers - that management interventions be treated as experiments as a way of overcoming uncertainty, system complexity and ignorance. This approach may have another function when funding is scarce - linking research to (better funded) development projects (Behnke).

This paper is about what is needed in the framework for action in terms of strategies to promote livestock research as well as improved linkages to technology transfer. The policy unit that is being advocated would do impact assessment, package research results in a form that would make them more palatable for public consumption and possibly consider the process of research formulation. It should be realized, however, that ISNAR is charged with doing this. Perhaps they could also play a role in the policy unit activities. The important point is to set up strong mechanisms to promote livestock development (Shapiro).

Part three: Options for increasing livestock's contribution from the major production systems

Moderators

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Rapporteurs

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Redesigning for risk: tracking and buffering environmental variability in Africa's rangelands¹

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¹ This paper is a slightly modified version of one with the same title which appeared as *Natural Resource Perspectives N° 1* published by ODI in November 1994

Introduction

The arid and semiarid zones cover about one third of the earth's land surface but nearly two thirds of the African continent. The majority of African livestock and possibly 30 million people dependent on livestock reside in these dry zones along with the greatest and most diverse concentrations of wild mammals still in existence (Ellis, 1994). Twenty of the world's poorest countries are found here. Economic considerations, environmental interest, geographical extent and human welfare suggest that African rangelands should be high on the development agenda but they are not. This paper discusses some of the reasons for the neglect and proposes some remedies.

Throughout the 1960s and 1970s the blueprint for African range and livestock development projects was the ranching model (Sandford, 1983). By the early 1980s poor project performance had subverted confidence in this model. A decade of experiments involving large (World Bank pastoral associations) and small (NGO water harvesting, restocking and paravets) donors ensued. This was accompanied by extensive field research (including pastoral systems studies conducted by the then International Livestock Centre for Africa) and theoretical retooling (notably in scientific ecology). Much of this was innovative and practical but it did not provide a framework for assembling new research ideas and intervention techniques into a more adequate policy for rangeland development. This now seems possible.

The ranching model projects of the 1960s and 1970s presumed that enlightened resource management was both intrinsically good and likely to provide economic dividends. Economics and conservation were linked by the presumption of pastoral overstocking (Behnke *et al*, 1993). Overstocking was supposed to explain why African pastures were degraded, herd output was low and pastoralists were poor. The problem with ranching projects, however, was that they could not deliver lower stocking rates.

The development initiatives of the 1980s, whatever their other successes, proposed few new

techniques for adjusting livestock numbers to forage supply on open rangelands. Recent advances: in scientific ecology and pastoral studies have also failed to "solve" the overstocking problem and have not suggested more effective ways of removing surplus animals. They have, however, encouraged a reframing of the problem.

The concept of the four horizontal rows (Table 1, Table 2) depicts relationships among the broad objectives to which a project contributes, the project's immediate purpose, its intended results and the activities it will support. The four vertical columns refer to aspects of this cause and effect sequence - the logical links among intentions and results, measurable indicators of performance, how to obtain data for assessments of performance and the assumptions underpinning each step of the exercise.

There are remarkable continuities and important changes in pastoral and range development projects from 1960 to the present (Table 1, Table 2).

Table 1 African rangelands - the ranching model of the 1960s and 1970s

Item	Intervention logic	Achievement indicators	Sources of verification	Assumptions
Overall objectives	Rangeland conservation	Botanical indices	Assess vegetation condition/trend	Stocking rate determines vegetation characteristics
Project purpose	Improve income from livestock	Animals sales	National accounts	Fewer animals = higher output
Results	Destocking	Lower stocking rate	Livestock census	Rangeland overstocked
Activities	Marketing, fencing, ranch demarcation, water development, etc			

Table 2 African rangelands - tracking and buffering range livestock projects in the 1990s

Item	Intervention logic	Achievement indicators	Sources of verification	Assumptions
Overall objectives	Sustainable rangeland production	Outputs/ha, trends over decades	Historical records, national statistics, modelling	Episodic ecological change
Project purpose	Improve income from livestock	Livestock output in cash/kind	Improved national accounts	Income subject to risk
Results	Track/buffer environmental fluctuations	Statistical measures of variance	Climate records, improved national statistics	High level of environmental variability
Activities	Service delivery, marketing, tenure rights, water development, etc			

Overall objectives

Both the former ranching projects and those now proposed share an important characteristic in that they are attempts at natural resource management. In this respect both the very old and the very new project formats are distinct from most pastoral development efforts of the 1980s. Typical projects of the 1980s sought to provide services, improve welfare, improve pastoral incomes or develop pastoral community organizations. They had little success in accounting for how these activities contributed to sustainable resource management and its links with economic development (Table 2).

There are, however, fundamental differences between the objectives of range resource management in the 1960-1970s and the 1990s. These changes are underlined by abandoning of the earlier goal of "rangeland conservation" (Table 1) in favour of "sustainable rangeland

production" (Table 2).

For rangeland managers of the 1960s and 1970s domestic livestock were an intrusive element that destabilized "natural" botanical systems. The notion that domestic herbivores were a foreign intrusion had considerable intuitive appeal in North America and Australia-where stock owned by Europeans had suddenly burst on the scene. The natural "before" and the disturbed "after" were clearly distinguished in historical time and the requirements of industrialized agriculture confronted a nostalgia for a bygone landscape. Concepts of plant community succession and climax provided a powerful theoretical rationale for the conservation of pristine rangeland flora. Traditional range management conceived in these terms was fundamentally botanocentric. The state of the vegetation marked the success or failure of a management regime with botanical indices such as plant population; vegetative mass and species composition providing evidence of range trend, condition and livestock carrying capacity.

Despite its enduring popularity this type of rangeland assessment suffered in Africa from several limitations. The distinction between natural and manmade vegetation caused philosophical problems and operational ambiguities. Humans, their fires, and domestic stock contributed to creating some of Africa's most productive and picturesque savanna landscapes. Parts of North Africa, on the other hand, are undoubtedly degraded by human use but have been so since Greco-Roman times.

The use of predominately botanical indices to assess the performance of a form of agriculture in which plants are not directly used or consumed by humans might also be questioned. Range vegetation must be eaten by animals if profits are to be made. In areas where rainfall is reasonably constant large livestock populations may indeed consume enough vegetation to alter the plant life that they leave behind. Range livestock production - like most forms of agriculture - may alter the natural vegetation to produce food, fibre and other goods for human use.

These botanical changes are not proof of degradation unless agriculture itself is equated with degradation and no distinction is made between agricultural systems capable of producing for prolonged periods and those that are not. The conservation of pristine vegetation is of less concern for agriculturalists than the expected length of time that output can be maintained from altered vegetative states under different management regimes. In short, the objective of botanical immutability is less useful than a workable notion of sustainability. These concerns are reflected by the indicators of project achievement stated as maintenance of livestock product output over an extended time (Table 2).

Project purpose

The common purpose of both old and new kinds of projects is to increase producers' incomes from livestock. What distinguishes the new type from its predecessors is the way livestock income is defined and measured. This is a more significant change than would first be suspected

Livestock income in the older ranching projects was effectively defined as cash from sales of animals for slaughter. This presumed that pastoral development was a matter of technology transfer. Most industrial ranchers supported themselves by marketing carcasses and it was thought that modern African pastoralists should do the same. Such reasoning was an important link in the logical structure, and hence the appeal, of ranching projects. The belief was that animal sales had three beneficial functions: increased pastoral incomes; destocking and conserving rangelands; and supplying urban consumers with an essential commodity (Table 1). There were no uncomfortable trade-offs and everybody was a winner (Kerven, 1992).

Applied research on pastoral economies over the last 10 years has explained why this scenario was too optimistic. This hinges on the volume and kind of produce yielded by pastoral herds. Contrary to the assumptions of the ranching projects, traditionally managed livestock often provide their owners with cash and in kind benefits in excess of those to be derived from additional animal sales (that is, unless meat prices increased). If urban consumers were to eat more meat they had to pay prices high enough to bid against the alternate uses of livestock in rural trade networks, for immediate household use, as inputs into other productive processes or for breeding or growing out. Herd structure studies also suggested that urban consumers (or pastoral cooking pots) were already claiming the categories of animals suitable for slaughter and having few other competing uses. In other words there was no vast underexploited reservoir of meat standing around on the range chewing its cud. Comparative studies also show that pastoral productivity consistently equals, and frequently exceeds, the calorie, protein or cash value of output per unit land area from ranches in comparable ecological situations. Rational pastoralists therefore took their place beside rational peasants in the academic and development literature of the 1980s. The great leap forward in pastoral output and income unfortunately never materialized. It had been based on an illusion all along.

There remains, nonetheless, scope for genuine improvement of pastoral incomes and output through increased commercialization of pastoral systems of production, product disposal and household provisioning. Raising pastoral incomes will therefore remain the purpose of the new generation of projects. The opportunity for these improvements is created by the difference between the calorie and cash terms of trade for livestock products and grain. With certain important exceptions, prices for grain, meat and milk are such that pastoralists obtain more calories by selling livestock produce and buying grain than they could obtain directly from consuming the protein rich products of their herds. For poor pastoralists this means a chance of survival despite reduced per caput herd wealth. For the rich favourable terms of trade provide an opportunity to improve their standard of living or to reinvest surplus earnings in pastoral production.

Commercial investment in pastoralism is needed since traditional production systems are well adapted to the demands of their natural environment and output per hectare is already high. Increased output is thus dependent on the use of new industrial inputs. If producers are to obtain the cash to purchase these inputs commercial livestock production is unavoidable. Indeed, it is not only unavoidable but is happening. Recent field research has shown that small scale commercial innovations are continuously undertaken in most pastoral economies. These spontaneous changes are the exact opposite of the carefully engineered leaps envisaged in the ranching model. The more modest pastoral development efforts of the 1980s also successfully promoted incremental changes.

Results

Maintaining a constant low stocking rate was the primary intended result of the ranching project. In hindsight, however, there was little scientific evidence that destocking programmes would fulfill their environmental objectives or increase total livestock output (Table 1). Lower stocking densities could, in fact, actually damage pastoral incomes.

Stocking rates low enough to ensure that forage shortages never occurred would be uneconomic to maintain in very dry environments with widely fluctuating rainfall. Economically optimal stocking densities also vary according to the kinds of products yielded by herds, the breeds and species kept and the husbandry techniques employed. Pastoral stocking densities may be too high to maximize beef production per hectare or to meet the botanical standards of professional observers trained in a ranching environment. These densities may, nonetheless, maximize the combined output of live animal products such as milk, traction,

manure and fibre. Destocking these "overstocked" rangelands would probably depress both individual and aggregate pastoral incomes. This probably explains the almost universal rejection by pastoralists of enforced destocking programmes.

Environmental benefits of conservative stocking regimes are as dubious as their alleged economic benefits. Irreversible changes in plant life occur episodically and not incrementally in climatically unstable environments. The dominant variables driving these ecological changes are physical factors, such as rainfall, outside management control. In these event dominated systems it is unrealistic for managers to try to forestall environmental change by tinkering with a single dependent biological variable such as livestock numbers. Managers who cannot control their environment must quickly adapt to it if they are to minimize the consequences of unpredictable rainfall fluctuations. This opportunistic approach to rangeland exploitation demands temporary but sudden and very substantial adjustments in livestock feed demand in response to precipitous changes in feed supply (Table 2).

Flexible strategies of resource exploitation must be profitable as well as environmentally beneficial if producers are to adopt them. In other words, environmental concerns must dominate project objectives but economic concerns define project purpose (Table 2). These dual intentions require both biological and economic indices of project success -tracking and buffering of environmental fluctuations. Tracking refers to the biological phenomenon of prompt adjustment of livestock forage demands to fluctuating levels of primary production. Buffering of environmental fluctuations refers to the economic phenomenon of shielding of pastoral incomes from the worst effects of violent climatological and biological fluctuations.

Quantifiable measures of project success are not the same for biological tracking and economic buffering. Parallel changes in livestock feed requirements and supply provide evidence of successful biological tracking. Economic buffering dampens the effects of environmental variability by creating more stability in the income from livestock than in rainfall or primary production levels. Range livestock development needs activities, or combinations of activities, that simultaneously produce high coefficients of variation for feed demand and low ones for the value of output. This is "opportunistic" rangeland management or the attempt to maintain large, healthy and productive herds that allow, when conditions dictate, removal of as many animals as necessary as quickly and profitably as possible.

Activities

Opportunistic resource management is not new to African pastoralists. Official endorsement of opportunism does not, therefore, demand the radical reform of existing husbandry systems. It does, however, bring government and donor management objectives into line with customary practices, anticipates evolutionary rather than sudden economic change and, belatedly, adds pastoral development to the growing list of participatory or client oriented forms of development. Responsible project design must, however, balance local and national interests, and match community priorities with wider policy concerns. Environmental tracking and economic buffering are among these concerns and provide criteria for screening local initiatives.

Field workers, often in conjunction with NGOs, have developed many new techniques for delivering services to pastoralists over recent years. These include improved systems for primary animal health care, water harvesting and storage, design of drought and famine early warning systems and postdrought restocking. All range livestock development initiatives already have a core of tested field techniques to draw on, reject or modify in the light of local circumstances and the policy framework (Table 2).

There is also scope for modifying existing project methods. Project components urgently in need of revision are those that are expected to perform new functions under opportunistic

management. In the older project framework drought was an emergency - an unexpected catastrophic event outside the parameters of normal planning. In the present framework erratic rainfall (that is, drought of varying severity) is viewed as a continual hazard. Incorporating drought into the concept of normal climatic variability demands a rethinking of how pastoral relief and development is to be achieved.

Famine relief

Emergency sales force many animals to market during droughts, forcing prices down when poor harvests and grain scarcities are causing cereal prices to rise. If market forces set food prices under these adverse conditions some pastoralists may starve unless they receive relief provisions. Development agents are therefore confronted with an apparent dilemma in that they either let human and animal populations "track" environmental fluctuations and people suffer or they "buffer" pastoral incomes from environmental stress but foster dependency.

A more attractive approach to providing relief would attempt to make sure high levels of grain were available through normal commercial channels. This could be achieved by bulk sales of relief supplies at concessionary prices. Hoarding and speculation would be controlled by adjusting the volume of external supply relative to the strength of internal demand. It would be necessary to maintain drought early-warning systems to provide information on the geographical extent and severity of a crisis in order to estimate these supply-demand factors but in order to influence these factors there would need to be adequate transport infrastructure and, possibly, transport subsidies to ensure that food moved in the desired direction. Consistent with the anticipated results of the project (Table 2) these arrangements would promote both buffering and tracking since pastoralists could maintain their incomes only by selling stock during droughts.

Livestock marketing

Tracking and buffering would also require improved livestock marketing systems. Livestock marketing was previously seen by project designers as a mechanism for maintaining continuous high offtake and low steady stocking rates to prevent overstocking and deaths of animals during droughts. Ecological research suggests, however, that livestock population crashes are unavoidable when rainfall is erratic. A more realistic project goal under these conditions is not to design marketing systems that can forestall fluctuations in throughput but to design systems capable of absorbing such fluctuations. Low cost techniques of meat preservation, improved transport infrastructure, access to the largest possible consumer market for meat and elimination of subsidized international competition may be components of this effort. Withdrawal of government regulatory agencies or marketing monopolies that add to the covert costs of trading, stifle competition and depress producer prices may be equally important.

Land tenure

Project managed land tenure reforms in the past attempted to limit herd growth by confining herds to restricted areas. Managers viewed permeable territorial boundaries as undesirable since livestock owners were thereby allowed to escape the negative effects of overstocking.

Opportunistic strategies of resource exploitation turn this reasoning on its head. Shortage of feed is often localized due to the erratic distribution rather than the total absence of rain. If adjacent grazing areas experience asynchronous productivity flushes, herd mobility - and non-exclusive tenure arrangements that allow it - are a cost effective way for animals to walk away from temporary local imbalances in stock numbers and feed supply. The practical question for project design is not how to eliminate non-exclusive tenure systems but how to ensure that pastoralists can take advantage of them.

Rangelands must be managed by local communities and government authorities. Government cannot intensively administer rangelands because their output is generally low and erratic and will not pay the costs of direct administration. The only economic solution is for users to bear the costs of resource management. They will be willing and capable of doing this only if they have proprietary rights. In pastoral areas, however, administrators cannot expect to allocate resources once and for all. These are environments where rainfall and forage productivity are fleeting resources. Human and livestock populations must rearrange themselves in space on a seasonal and interannual basis. By conferring basic property rights on producers and local communities impartial intercession will still be required to sort out the conflicting, shifting and multiple entitlements implied by these rights. In order to be able to do this local government authorities must establish their neutrality, institute procedures for conflict resolution and enforce their decisions.

Cultivated forage

Past forage development programmes concentrated on improving yields from cultivated fodders. Opportunistic management would put less emphasis on the search for yield increases and concentrate on production of forage when it was most needed in low rainfall years. Measures of success would be indicated by yields which were less variable than those from surrounding natural vegetation and improved profits from livestock resulting from a greater total feed supply.

Conclusions

A review of existing research (Scoones, 1994) has produced recommendations for project activity in the areas discussed in this paper. Field research on problems of opportunistic management would undoubtedly produce more precise recommendations or increase confidence in those already proposed.

In the short term what is left is a mixed picture. Some activities such as paraveterinary programmes, water harvesting and famine early warning systems are ready for large scale use. Other potential project components such as famine relief, land tenure, livestock marketing and forage production still need research and field experimentation but are likely over the long term to improve the tracking and buffering of environmental variability in Africa's rangelands.

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Mixed farming systems in sub-Saharan Africa

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Introduction

Development objectives for sub-Saharan Africa are moving towards resource conservation and natural resource management while striving for greater agricultural production. Economic growth must increase by 4-5 per cent annually if food security is to be achieved and a modest standard of living provided for the 1.3 billion people expected in the region by 2025 (World Bank, 1989). Rapid urban population growth (55 per cent of Africans will live in urban areas in 2025) and higher income will create a need for better quality food, particularly of animal origin, from a rural population that is expected to feed 592 million by 2025 compared to 350 million in 1990. This is an enormous challenge in a region that experienced a negative per caput GDP during the 1980s. The 3.2 per cent average annual population growth and severe financial and environmental crises portend an even gloomier future.

Agricultural intensification is inevitable in sub-Saharan Africa and livestock are critical to the development of sustainable and environmentally sound production systems. Intensification has occurred gradually over many years in other developing regions but in Africa it will need to happen over a very short time due to rapid population growth. Past research and development efforts which promoted crop-livestock systems have failed to bring about the desired agricultural transformation. Some of the problems to be tackled are:

- the role of mixed farming in sub-Saharan Africa's future agriculture;
- obtaining a better understanding of crop-livestock relations in an attempt to make mixed farming a favoured option for intensified land use;
- identification of knowledge gaps; and
- the needs for popularizing mixed farming.

This paper reviews the important position and role of mixed farming systems in land use intensification in sub-Saharan Africa.

The farming situation in sub-Saharan Africa

The origins of agriculture in sub-Saharan Africa remain unclear. Vegeticulture was probably practiced on the northern margins of the tropical forest as long as 7000 years ago but the beginning of cereal cultivation is less clear. Sub-Saharan Africa had a limited range of crops when Europeans first arrived in the 15th century, the most important being sorghum *Sorghum vulgare* and several millets. In parts of West Africa indigenous yams, rice and banana were grown. New food crops, including cassava and maize, were introduced after the discovery of the Americas. The first cattle entered Africa through Egypt about 7000 years ago. The plough, by then present over most of the Old World, did not reach Africa until the 19th century except in Ethiopia. Unlike Asia, animal and arable agriculture were generally separate in Africa and could have been a barrier to early intensification.

Sub-Saharan Africa is essentially a continent of small holders and its environments are very sensitive. At relatively low population densities traditional methods start to degrade the soil and threaten future production. Climatic realities result, except in the humid zones, in frequent crop failures from drought or dry spells in the growing season. Most African soils are derived from highly weathered granite and gneiss parent material. Soils are thus coarse with low contents of fine clay particles and organic matter and are deficient in most nutrients, especially nitrogen and phosphorus. The water holding capacity of African soils is poor so rainfall leaches out soluble nutrients. Soil organic matter is rapidly decomposed under high temperatures except in the cooler highlands. Once vegetation is removed water and wind erosion remove the top soil, the surface crusts easily and is then sealed against infiltration.

As cropped areas expand fallow periods shorten progressively. Short fallows do not allow regeneration of soil fertility, produce little fuel wood and are a poor grazing resource. The crop residues and dung that are so desperately needed to maintain soil structure and fertility are increasingly burnt for want of alternative fuel sources. Communal or uncertain land tenure over most of the continent only makes the development task harder.

Most farms in sub-Saharan Africa intercrop anything with everything. Growing a mixture of crops and varying land management are strategies for adjusting to different soil and water regimes. Intercropping provides a protective cover of vegetation which lowers soil temperature, increases water infiltration, helps to prevent soil erosion, lowers the incidence of pests and diseases and reduces labour needs for weeding. By combining different heights, root depths and maturity periods intercropped plants complement each other in the use of light, water and nutrients. The total output of intercropped areas is usually greater than monocrops but yields have stagnated or declined in the absence of soil fertility replenishment. Use of fertilizers compensates for shortening fallow periods but farmers in many countries have no incentive to use them because prices for farm produce are not sufficiently attractive or fertilizers are not readily available.

Why mixed farming?

The short and simple answer to this question is that it increases the bioenergetic efficiency of agriculture and preserves environmental quality. Production objectives should be to:

- optimize output over a long period;
- maintain diversified agroecosystems with components having complementary functions;
- build up soil fertility and prevent nutrient losses;
- provide continuous vegetative cover possibly by the use of legume based rotations or green manure; and
- limit imported fertilizer applications and pesticide use.

The case for integrating animal and crop systems is based on the premise that by-products

from the two systems are used on the same farm. Draught power, closed nutrient cycling, improved environmental quality and use of roughages and low quality feeds contribute to overall higher output per animal and per hectare. Soil fertility improvements result from the volume of organic components that circulate through the soil and plants and the animal manures that enrich the soil through long lasting carry over effects. Livestock also provide a ready means of acquiring cash and support the use of inputs in crop production which in turn generates higher levels of output from both crop and livestock (Brumby, 1986).

Land use changes in sub-Saharan Africa

Livestock have played a pivotal role in intensification of farming in most parts of the world. The biogeography of sub-Saharan Africa blocks the full promise of livestock in farming systems. Over much of the continent the tsetse fly vector of trypanosomiasis effectively separates crop and livestock production.

The two activities are properly integrated in the East African highlands where temperatures are too cool for tsetse (Table 1). Recent climatic changes, bush clearance for agriculture and specialized tsetse control programmes have increased areas that are free of tsetse and made them suitable for livestock-crop integration (Jabbar, 1992).

Table 1 Major agricultural systems in sub-Saharan Africa

Zone	Crop/livestock integration	Major agricultural systems	Major livestock outputs
Humid	Pure crop	Forest/permanent trees: roots/cereals (trypanotolerant livestock)	Periurban milk
Subhumid	Crop-livestock	Cereals (maize/sorghum)- livestock	Meat, milk, power
Highland	Well integrated crop-livestock	Cereals (wheat/teff)- livestock	Power, meat, milk
Semiarid	Livestock-crop	Cereals (sorghum/millet)- livestock	Milk, power
Arid	Pure livestock	Pastoral	Milk, meat

Most potential for fodder production is in the humid zone which currently has few livestock. Major concentrations of livestock are in the semiarid zone despite its low potential for supplying fodder all year round. Settled arable farmers in dense tsetse areas do own livestock but these are entrusted to professional herders in tsetse free areas and to avoid disputes over crop damage. The benefits of draught power, milk and manure from livestock integration are lost under these arrangements.

A general rule of agricultural development is that land is more intensively used as population density increases. In West and East Asia transition to intensive farming became possible with irrigation. Transition in the Middle Ages of Europe occurred with more sophisticated crop rotations involving legumes and integration of livestock with arable fanning. None of these conditions prevails in sub-Saharan Africa to assist in the transition process.

Crop-livestock integration seems to be a response to different supply and demand patterns in factor and output markets, agroclimate and population growth. The need for crop-livestock integration is low at low population density as there is little demand for animal power, manure or crop residues for fodder. Interactions by exchange of products take place without integration of livestock and crop enterprises on the farm. Soils, land form, market access and income create diversity within and between environments. Land use intensifies by reducing the fallow period to increase cropping frequency as land prices increase in response to population pressure. Where fertilizers are not easily accessible croplands are manured by paddocking animals or transporting manure from night pens. Mulching is practiced in areas

unsuitable for animals. Land able to store or provide water becomes a target for intensified use as populations increase. Demand for power encourages integration of animals in farming systems.

There is, however, no consistent association between agroclimate and population density. When animal traction is cheaper than hand cultivation the choice for the farmer is to rent or own draught power. When manuring is necessary to replace fallows the choice between manuring contracts and livestock integration depends on farming intensity and the transaction costs of substitutes (McIntire *et al*, 1992). As manure becomes scarce (herders also need it as they now use it on their plots) and fertilizers are unavailable farmers resort to manure-transported mixed farming. At high cultivation densities crop residues are more important because the area of natural pasture declines. Herders gain access to crop residues by entering into contract grazing with farmers or by producing crop residues directly. As farmers gain knowledge of livestock production they start keeping animals in pens and feed them crop residues to produce manure and to provide traction. Crop-livestock integration is thus encouraged at both ends of the spectrum of pure pastoralism and pure cropping (Table 1).

Constraints

Every zone in sub-Saharan Africa has a meat and milk deficit. The favourable market for these products could encourage livestock productivity improvements through land use intensification. Integration of crops and livestock has been the objective of past agricultural development in sub-Saharan Africa. Mixed farming was a development goal early in the 20th century in northern Nigeria as shown by selection for improved draught qualities as well as meat and milk (Straw and Colville, 1950).

Loans have been provided under various development schemes to allow farmers to buy animals and field equipment. Where animal draught is used it allows an increase in the area cultivated. This has largely occurred as a result of the introduction of cash crops, the profit from which financed the purchase of draught animals and equipment. This process of expansion occurred when land was abundant in relation to labour by encouraging expansion into virgin lands and subsequently to fallow lands.

There are other examples of cropping systems incorporating livestock to take advantage of manure or crop residue feeding, transport and possibilities for wealth accumulation. The level of integration is a function of:

- environmental differences between the two enterprises;
- factor and input substitution;
- year round feed supply, stock feeding and management;
- high labour inputs reducing incentives to keep livestock until output prices rise in relation to the opportunity cost of family labour;
- alternative investment opportunities; and
- benefits from integrated systems.

Benefits to integrated crop-livestock systems are sometimes small from manure, crop residues and draught power (McIntire *et al*, 1992; Williams *et al*, 1994) implying that exogenous technical changes including improved seeds, fertilizer, water and nutrient management are needed to raise overall productivity.

The process of integrating livestock in crop systems is initiated when two independent complementary systems interacting through the exchange of byproducts compete for the key production factor, land. Competition for land and labour is between the end users of crops versus livestock, resident and immigrant farmers for crop land and village livestock owners and pastoralists (Speirs and Olsen, 1992). Population increase does not only take place by natural growth but also by migrant influx. The potential for conflict for labour between crops and animals will differ in land scarce and land abundant situations. Manure collection, for example, is labour intensive and manuring thus depends on labour availability. Land scarcity contributes to declining fertility as fallow periods are reduced, and rising land values lead farm households to escalate the process of securing land. As competition for land increases conflicts are inevitable, especially where traditional systems of verbal usufruct agreement are misinterpreted or owners have difficulty in recovering land from those claiming "squatters rights". Migrant inflow also accentuates conflicts over use of crop residues, fallows and access to dry season forage and water. Customary property institutions in Africa define different types of rights for the resources used and these constitute barriers to long term investment. Traditional leaders have also lost their authority to determine property rights and governments lack the capacity or the infrastructure to define and enforce them.

A certain level of population and reasonable market access are required for successful mechanization. Economic distortions in many sub-Saharan Africa countries since independence have affected the process of agricultural intensification. Cash crops and minerals continue to be the main sources of foreign exchange and government revenue. Fluctuating commodity prices contribute to variable trade balances and budgets and make long term planning impossible. Frequent changes in key personnel by donor governments and changes in aid or loan conditions have impaired the bilateral and multilateral development programmes. In the short period since independence the development consensus for sub-Saharan Africa has shifted from high to low to mixed technology, from project aid to aid designed to influence policy, from enthusiasm for populist approaches to privatization and from encouraging population growth to cuts in aid to those populations. These factors continue to impair independent long term policy formulations and implementation by sub-Saharan Africa countries.

Domestic production has also suffered from a policy priority to supply urban areas with cheap milk and meat as well as government price controls and over valued exchange rates. Technological innovation, infrastructure and extension services have not catered for the changing circumstances of the farmer. Farmers moving to marginal areas continue to use the traditional techniques which failed to sustain productivity even in the agriculturally better lands they abandoned.

The arid zone has the lowest capacity to supply human needs but ruminants in traditional nomadic and pastoral systems are well adapted to converting pasture and browse into food and income. Increasing human populations and the spread of cropping into marginal lands reduce the ratio of range to crop land and create serious environmental concerns. Integrated wild life-domestic livestock systems may be more sustainable in this zone. In the wetter part of the semiarid zone, however, favourable cropping conditions and the absence of trypanosomiasis are conducive to the expansion of mixed farming.

In the subhumid zone abundant cattle, low trypanosomiasis challenge, strong product demand, level terrain and proximity to areas of animal draught reserve and cultivation are factors that should have favoured wider use of animal traction and mixed farming. Lack of farmer knowledge has been identified as a major cause for the failure of animal traction to spread southwards in the subhumid zone. Soil hardness, trypanosomiasis and cropping patterns that were believed to constrain expansion of mixed farming were not, on the other hand, found to be important (Blench, 1987). The knowledge gap is not insurmountable, however, as people elsewhere have learnt to use animals and other technologies within a

short time. In the northern subhumid and the semiarid zones it is possible that mixed farming did not develop because early planting to make use of the short rains and growing period is a greater priority than tilling of the predominantly sandy soils.

In the humid zone the major factor limiting ruminant production is trypanosomiasis. Livestock expansion by clearing forests is not environmentally desirable but there are opportunities for integrating trypanotolerant livestock into permanent tree systems.

The highlands ought to favour field mechanization because of high population density, continuous cultivation and relatively heavy soils. Very steep slopes and erosion risk impose, however, a certain cropping pattern and very small farm sizes do not require mechanization or individual ownership of draught power. Hiring is thus a cheaper way of using animal traction. Production increases in the highlands must come, however, from further intensification of the crop-livestock land use systems.

Disease can be a major constraint to integrating cattle in crop farming. Trypanosomiasis is the most important disease in sub-Saharan Africa and is followed by tick transmitted and tick associated diseases and internal parasites. Diseases whose importance increases as production systems intensify include soil borne bacterial diseases such as anthrax, infectious diseases of the reproductive tract including brucellosis, diarrhoea, pneumonia, mastitis and mineral deficiencies. These must be controlled to assure farmers that intensification will yield adequate returns to their investments (Winrock, 1992). The inability of many countries to maintain effective surveillance and control measures and ineffective delivery of veterinary services throughout sub-Saharan Africa are major impediments to effective disease control. Indigenous ruminant sources of resistance or tolerance to disease are currently poorly characterized and inefficiently used.

In all sub-Saharan countries population density has yet to reach the level where intensive farming becomes unavoidable. It has, however, reached the level where massive ecological damage will occur if traditional methods continue to be used. Governments can assist the intensification process by supporting new technology generation and transfer and by favourable policies to improve markets, infrastructure and other facilities for agriculture.

Research

Countries in sub-Saharan Africa must seriously consider agricultural intensification, before population density compels them to do so, in order to meet future food needs. Intensification can be accelerated through research which should consider socio-economic, natural resource, technical and institutional factors that influence productivity and sustainability. Inability to feed animals adequately throughout the year is the most widespread technical constraint for livestock producers. Seasonal feed availability from natural resources is affected by land competition resulting from population growth.

Commodity research programmes have neglected mixed farming systems. Extension services split into crop and livestock sectors have exacerbated the problem. The possible benefits from crop-livestock integration have thus not been fully exploited. In many cases technologies have been extended beyond the ecological limits and to areas where returns to labour were inadequate or where there were other promising opportunities (McIntire *et al*, 1992).

Socio-economic and biophysical flows run in parallel and are interdependent on a farm. Socio-economic inputs are land, labour, capital, culture and knowledge whereas outputs are fulfilment of life needs including income, health, knowledge, social stability and a sense of community. Physico-chemical inputs include energy for operations such as tillage, harvest, fertilization and pest control. Biological inputs include organic matter such as crop residues, animal manure, legume nitrogen, cover crops, rotations and cropping patterns (Grove and

Edwards, 1992). In mixed farming systems there are opportunities to increase land productivity by optimizing the value of biophysical inputs. Use of genetically improved crops for high photosynthetic rates and animals capable of converting cellulose tissues in the rumen are examples of this.

Biophysical considerations

Plants have the ability to capture and use solar energy. The range of life in any particular location is limited by temperature and moisture. Within the bounds of varying climate, season and terrain the diversified biomass interacts among itself and with the soil to establish a self-regulating ecosphere. The desired cyclic relationship is distorted in modern agriculture and the fight against pests and diseases -normally kept in balance in natural ecosystems -requires major effort. Wastes in modern agriculture have also become a practical and social problem and recycling them has not been seen as an ecological resource renewal procedure.

Biological diversity and nutrient cycling are common processes in the functioning and persistence of agroecosystems (Grove and Edwards, 1992). Development of sustainable mixed farming systems therefore depends on understanding the mechanisms controlling the kind and amount of biodiversity and the factors governing rates of mineralization and recycling of the organic matter fractions that stabilize the systems. Crop-livestock integration increases diversity in farming systems and provides a management tool for improving net production, stabilizing agriculture and protecting the environment.

Table 2 Nutritive value (per cent) of barley, wheat and teff straws

Component	Crop and maximum and minimum value					
	Barley		Wheat		Teff	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Crude protein	1.8	5.4	1.5	2.5	2.9	5.6
IVDMD	40.7	73.1	41.7	59.1	33.7	69.8

Feed development

Feed supply is a primary constraint in sub-Saharan Africa. Seasonal shortages are determined by the length of the growing period, cropping intensity and stock numbers. In mixed farming systems feed for livestock can be improved by:

- selection of crops having higher nutritive values in their residues;
- intercropping herbaceous and tree legumes with grain crops for higher fodder biomass production and nutritive quality per unit area; and
- creating fodder banks as supplementary source of seasonal feed.

Past efforts in crop improvement have increased the grain value of crops for all the target zones. Crop residues are an important livestock feed and replace natural pastures at high cropping intensities. There is inter and intra species variation in the nutritive value of crop residues at similar grain yields (Table 2) and selection for higher feed quality among crops capable of adapting to several ecozones should be a priority in crop improvement programmes.

Intercropping is a well established land use technique in sub-Saharan Africa. Where land is in short supply and feed is deficient, as in the Ethiopian highlands, human food and animal feed production must be maximized on the same land. Compatible associations are possible between food and forage crops (Table 3, Table 4) where forages in the mixture benefit from

husbandry practices on crops. Concurrent management for different outputs from the same land is, however, difficult as forages have better nutritive value in the vegetative state and grain formation in cereals starts only after completing the normal vegetative growth. Spatial and temporal complementarity are achieved by reducing competition for the same growth resources among the different components in the mixture. Crop-forage combinations therefore need to be adapted for different ecozones. Forage species need to be selected for complementary growth and maturity. Deep rooted trees are a good source of fodder during the dry seasons and their integration into farming systems, particularly in the humid zones to serve multiple needs, is a valid research area.

Table 3 Grain and fodder yields of crop-forage combinations on drained vertisols

Crop rotation	Yield (tonnes/ha)	
	Grain	Fodder
Oats/vetch- roughpea		
Oats/vetch	-	6.00
Roughpea	0.88	1.01
Wheat-chickpeas		
Wheat (variety Enkoy)	1.60	3.20
Chickpeas	1.39	2.16
Intercroppe wheat/clover		
Wheat (variety Enkoy)	1.01	2.84
Clover	-	2.50
Maize/Leucaena alley crop		
Maize	2.27	3.19
Leucaena	-	2.56

Table 4 Yields of sorghum and various inter-sown forage legumes cut twice per year

Crop	Component (tonnes/ha)	
	Grain	Fodder
Sorghum	2.0	8.7
Forage legume		
Vetch	2.3	8.5
Clover	1.4	6.9
Cowpeas	2.9	8.5
Lablab	1.8	9.1

Cultivation intensities tend to change the pattern of feed availability. At low population and cropping intensities the dry season is critically short of quality feed, especially protein, in all ecozones. Energy is also short in the arid, semiarid and at the drier end of the subhumid zones. At higher population densities with expanded areas of crop land the large amounts of biomass available after harvest compensate for the loss of natural dry season pastures. There is, however, a feed constraint during the wet season as most land is occupied by crops and livestock have limited access even to fallow lands because they are locked up within cropped areas. Providing a renewable source of feed supplement by establishing fodder and protein banks is possible. Research is needed in this context to predict future land use changes and to be able to tailor feed production and utilization strategies to the various ecozones and production systems.

Nutrient management

An important link in mixed farming systems is the cycling of natural vegetation and crop residue biomass between livestock and soil via faeces and urine. Nutrient deficiencies are common in sub-Saharan Africa and livestock can contribute to imbalances by excessive removal of vegetation while grazing and in harvested feeds and by not recycling nutrients or depositing them unevenly on the land. Seasonal and annual fluctuations of feed quantity and quality affect the number and type of animals that farmers keep and thus affect manure quantity and quality and its effects on crop production, especially in the semiarid zone. Because nutrient mineralization and losses are influenced by manure handling, storage and application there is a need to develop techniques to improve manure quality and nutrient recovery. In view of the competition between livestock and soil for cereal stovers and crop residues long term trends need to be assessed in terms of plant, animal and soil productivity. The value of legumes in improving feed quality and in contributing to the total nutrient economy of mixed farming systems also needs to be understood.

The biological processes regulating nutrient inflow in mixed farming systems are mediated mainly by socio-economic factors. As most aspects of intensified manure management depend on the labour available to collect, process, transport and spread it on crop land and the availability of cash to build pens and for purchase of animals and carts, development policies need to consider these factors. Assessment of temporal and spatial total factor productivity by quantifying changes in stocks and soil nutrient flows and the effect of material inputs and outputs on productivity may assist in understanding the sustainability of the systems.

Dual purpose livestock

Where mixed crop-livestock farming is well integrated, particularly in the Ethiopian highlands, further intensification and productivity can result only from improving energy use efficiency by livestock. Work oxen provide farm power but are used for only 8-10 weeks in the year. Ethiopia has up to seven million work oxen and there are 3-4 times more cattle than this for oxen replacement. All these compete on the same communal feed resource with other livestock. Use of cows for both milk and draught can potentially reduce the large herd kept for work oxen replacement and reduce overall grazing pressure. In order to integrate dual purpose cows into mixed farming systems there is a need to understand the functional relationships among milk production, reproduction, feed energy utilization and draught work and then to test the on-farm technical and economic performance and social acceptability of using cows for traction.

On-station experiments with F₁ Friesian × Boran and Simmental × Boran cows carried out by ILRI and the Ethiopian Institute of Agricultural Research show that both milk and work output are satisfactory if nutrition is adequate (Table 5). Limited on-farm tests are showing substantial increases in household incomes and farm outputs as a result of milk sales, cow traction and reduced numbers of work oxen.

Animal health

The major animal health problems in sub-Saharan Africa are parasitic and viral diseases, some of which are transmitted by arthropod vectors. These are widely distributed but their severity is strongly influenced by environmental conditions (Winrock, 1992). A large group of infectious and noninfectious diseases will become more important as production systems intensify. Interactions among disease, genotype, management and environment in the various production systems must be understood in order that integrated disease control strategies can be developed.

Genetic improvement

Most indigenous livestock in sub-Saharan Africa have evolved to cope with the harsh environmental conditions. The research challenge is to improve productivity without losing the adaptive traits essential to survival (Winrock, 1992).

Natural resource management

Research must develop technologies that maintain effective interactions among crop, fallow and rangelands. Most damage outside the crop land that disturbs the ecological balance is caused by soil erosion as the protective plant cover is removed. Grazing can incapacitate plants by preventing seed formation and reducing regenerative ability. Data on the effects of grazing impact on vegetation dynamics and nutrient flow and transfers are needed to design management strategies for sustaining crop and livestock productivity and rangeland and soil quality in the mixed farming agroecosystems.

Table 5 Cumulative milk yields of crossbred cows under various work and nutritional treatments

Treatment	Milk yield (kg) in specified number of days		
	0-365	0-730	0-1095
Not worked, not supplemented	849	1226	-
Not worked, supplemented	1792	3186	4502
Worked, not supplemented	802	927	-
Worked, supplemented	1770	3044	4050

Policy research

Identifying policies to facilitate the development of sustainable land use systems deserves high priority. Autonomous intensification as a result of the effects of population growth on factor scarcity and the free play of market forces is by itself unlikely to achieve the expected gains in per caput agricultural production and rural income (Lele and Stone, 1989). Land use planning needs to be guided by a knowledge of land suitability potential so that higher value and higher yielding crops can be grown on the most productive land. Land use rights, production incentives and market strategies are important policy issues. There is a need to evolve a management process for integrating several land use options at the geographical catchment level to serve the multiple needs of communities. Cooperation by the whole community should be fostered for management of the common resources that affect crop lands. The mechanisms needed to effect changes in common resources governance and for technology transfer are also issues for policy research.

Conclusions

Strategies designed to raise the productivity of specific mixed crop-livestock systems must consider the stage of development of the target area in relation to intensification and the nature of crop-livestock interactions, the availability and cost of inputs, and whether or not policies favour mixed farming. No single set of actions is applicable to all situations. Mixed farming systems are an option for increasing agricultural productivity while ensuring environmental safety in the semiarid, subhumid and highland ecozones of sub-Saharan Africa. Past efforts to encourage mixed farming failed because of the wrong policies and issues that were pursued and promoted by scientists and development agents.

Mixed farming is developing naturally in many areas of sub-Saharan Africa. At present economic levels livestock seem a viable alternative to manual labour, help to replenish soil

fertility and provide cash income for household needs. Production increases need to be rapid and sustainable and guarantee the well being of all. In order for this to be achieved political will and national commitment need to enact the required policy changes to intensify agriculture.

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Livestock, feeds and mixed farming systems in West Asia and North Africa

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Introduction

This paper looks forward to the year 2020 in the West Asia/North Africa (WANA) region. The region extends from Morocco in the west to Pakistan and Afghanistan in the east, and from Turkey in the north to Ethiopia and Yemen in the south. The prospects for crop (and crop residue) production, rangeland capacities and livestock and feed deficits are reviewed. Several case studies of flock level diet calendars for small ruminants and whole farm economic views of mixed crop-livestock systems are presented. The ways in which microlevel balances help in understanding how livestock management options affect cropping decisions while macrobalances at country level determine the economic contexts of livestock production are demonstrated.

WANA is the centre of origin of wheat, barley, lentils and chickpeas, and of sheep and goats. It is also the birthplace of Judaism, Christianity and Islam. WANA held the non-European parts of the Greek, Roman, Ottoman and Persian Empires. The region comprises the Arab countries and several of today's largest non-Arab Islamic countries. This "social ecology" of WANA must be respected and remembered in any discussion of "ecoregions", particularly when it comes to matters of management and policy in agriculture. WANA farming systems thus differ from areas in Australia, California, Chile and South Africa with similar crops and climates. "Farming does not take place in a cultural vacuum" (Fadda, 1992).

WANA is characterized by high population growth, low and erratic rainfall, limited areas of arable land, some of the world's biggest and harshest deserts and limited water resources for irrigation. Climates vary from Mediterranean to monsoonal and from temperate to tropical (Tutwiler and Bailey, 1991).

There is great diversity in the countries of the region in terms of trends in human and ruminant livestock diets over the 1970-1990 period and the differential prospects for domestic food and feed production in relation to projected human populations for the years 2000, 2010 and 2020. Food and feed production prospects are contrasted in 18 of the 25 countries considered by ICARDA as part of its WANA region: Afghanistan, Algeria, Egypt, Ethiopia, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Oman, Pakistan, Saudi Arabia, Sudan, Syria, Tunisia, Turkey and Yemen. Other sources (TAC/CGIAR, 1992) consider Ethiopia and Sudan to be part of sub-Saharan Africa and Pakistan as part of Asia so these countries are considered separately here.

Food in WANA

The Mediterranean diet, rich in cereal starch and olive oil, is famous for its healthy qualities (Spiller, 1991). Human diets, with the exception of a few countries, clearly improved over the 20-year period 1969-1971 to 1988-1990 (Figure 1) in terms of greater daily per caput protein and energy intakes (FAO, 1993b),

Protein derives chiefly from plant sources (mainly wheat) in ratios of at least 3:1 with animal sources including milk products, eggs, meat and fish (Figure 1). Sudan, where pastoral cattle keeping is important, and the oil states of Saudi Arabia and Libya are exceptions with ratios of less than 2:1. Diets in WANA contrast strikingly with those in the US, UK, France and Japan where most protein is from animal sources. Plant sources, such as wheat - as bread, couscous or burghul - potato and sugar contribute the predominant shares of energy in WANA diets (Figure 1). The contrast with Western countries is again remarkable, due to the high levels of animal products in their diets.

National diet figures mask differences within countries. There is no doubt the wealthiest segment of each population includes greater proportions of animal products in its diet whereas the urban poor has the least. The prospects for large deficits in domestic feed production in WANA in the future may mean even lower quality diets for the poor.

Oil wealth and population

Discussions about world food prospects find it convenient to generalize about geographic groups of countries but the plight of the poorer countries in a region is masked by averaging their lot with that of richer neighbours. This criticism can be levelled at three recent analyses (Alexandratos, 1993; Mitchell and Ingco, 1993; Rosegrant and Agcaoili, 1994) which seem over optimistic in concluding that WANA will not face a food crisis (Nordblom and Shomo, 1994). WANA countries need to be sorted into groups based on their oil wealth and populations (Table 1) as a first step in ensuring that the region's food and agricultural problems will not be ignored.

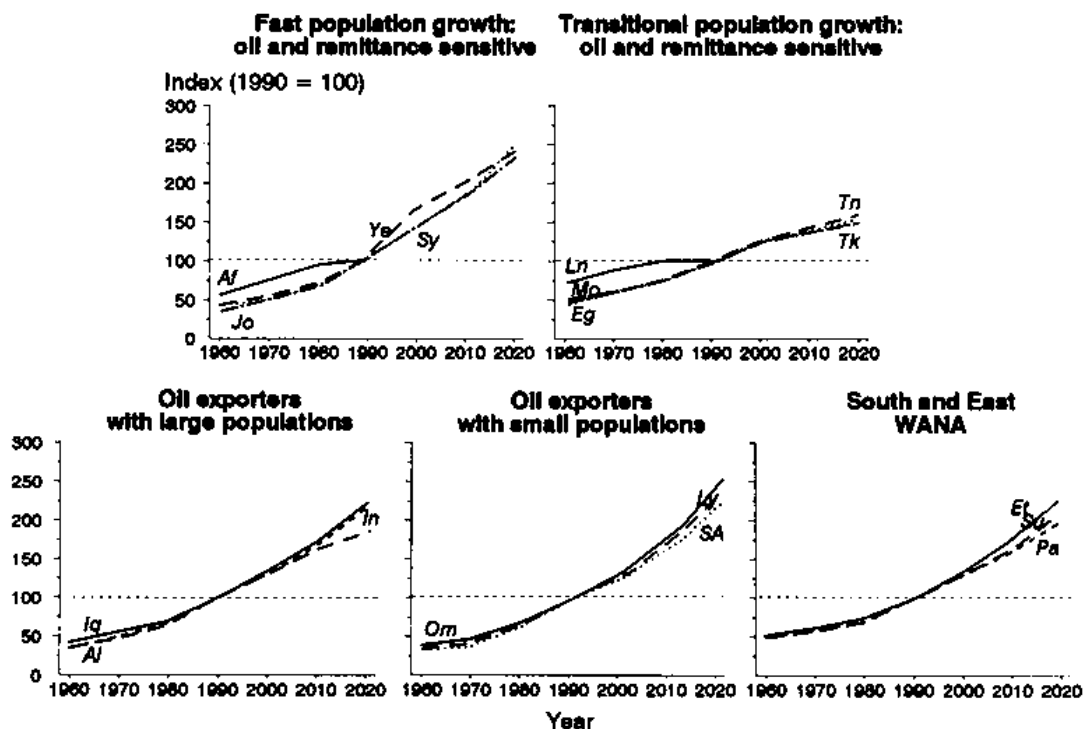
Fast population growth: oil and remittance sensitive								
Yemen	515	5.2	6.3	8.2	11.7	16.4	22.6	30.1
Afghanistan	675	10.8	13.6	16.1	16.6	26.5	33.5	41.6
Syria	1000	4.6	6.3	8.7	12.4	17.5	24.2	31.6
Jordan	1120	1.7	2.0	2.9	4.0	5.6	7.6	9.7
Average/total (1990)	763				44.7			
Transitional population growth: oil and remittance sensitive								
Egypt	620	25.9	33.0	40.9	52.4	64.8	77.7	88.5
Lebanon	812	1.9	2.5	2.7	2.7	3.3	3.8	4.2
Morocco	1030	11.6	15.0	19.4	25.1	31.6	38.7	44.6
Tunisia	1510	4.2	5.0	6.4	8.1	9.8	11.3	12.7
Turkey	1820	277.5	35.3	44.4	55.9	68.2	79.0	88.0
Average/total (1990)	1210				144.2			
Oil exporters with large populations								
Algeria	2020	10.8	14.0	18.7	25.0	32.9	41.5	48.0
Iran	2320	21.6	28.0	39.3	58.0	77.9	104.0	132.0
Iraq	3657	6.8	9.0	13.0	18.0	24.8	32.9	41.8
Average/total (1990)	2484				101.0			
Oil exporters with small populations								
Libya	460	1.3	2.0	3.0	4.5	6.5	8.7	11.4
Oman	5650	0.5	0.7	1.0	1.5	2.2	3.0	4.1
Saudi Arabia	7060	4.1	5.7	9.4	14.9	20.7	27.8	36.1
Average/total (1990)	5538				20.9			
South and East WANA								
Ethiopia	120	24.2	30.6	38.7	49.8	67.0	89.0	116.0
Sudan	370	11.2	13.9	18.7	25.2	33.2	43.0	54.5
Pakistan	400	50.0	65.7	85.3	118.0	154.8	197.7	240.9
Average/total (1990)	324				193.0			

Source: GNP data from USDA, 1993b for 1990 or nearest year except Afghanistan. Iraq, Lebanon, Libya, Sudan and Yemen for which source is EIU, 1992 and for which data are GDP; population data are from UN, 1993

These groupings are somewhat arbitrary but serve to demonstrate the disparities in WANA and between WANA and other areas. Average GNPs per caput of the five WANA groups in 1990 were US \$ 763, US \$ 1210, US \$ 2484, US\$ 5538 and US \$ 324. GNPs in developed countries in 1990 were US \$ 16000 in the UK, US \$ 19400 in France, US \$ 21900 in the USA and US \$ 25800 in Japan (World Bank, 1993). The western stereotype of the "rich Arab" is most inappropriate for the great population masses of WANA.

In addition to large differences in GNP, oil wealth, significance of remittances and the size and expected trajectories of their populations, the WANA countries show great differences in agricultural potential due to unequal endowments of soil and water resources.

Figure 2 Relative population trajectories in WANA countries (Source: UN, 1993)



Land policy

Contested land ownership and tenure in WANA has a 5000-year history (Nordblom, 1992). Successive civilizations have rejected and borrowed parts of previous institutions in forming new ones for dealing with land resources. After the Islamic conquests only urban property was privately owned whereas farm and pastoral areas were community property. Towards the end of the Ottoman Empire (19th to early 20th centuries), however, communal or tribal types of land tenure in the main agricultural areas were replaced by forms of private ownership.

The Ottoman Land Code of 1858 introduced order to the mass of earlier legislation and was the legal basis of tenure in Syria and Iraq until the 1930s. It defined five categories of land (Warriner, 1962):

- Mulk, held in absolute freehold and governed by sacred, not civil statute law, conferred the right of absolute ownership and usufruct of the land, both rights belonging to the individual;
- Miri is in the absolute ownership of the state but usufruct rights belong to the individual in a form of heritable "ownership" through which the state leases land to him;
- Waqf is land dedicated to religious and benevolent purposes such as mosques, schools and hospitals;
- Matruka land is reserved for public use such as roads, rivers, buildings, market places and village threshing floors; and
- Mawat or Mubah is unreclaimed desert or empty land in the property of the state in the sense of absolute ownership but bringing such land under cultivation over a fixed period confers Miri rights.

Land reforms were implemented by most Arab states and Iran in the 1950s and 1960s. The stated aim was to redress gross inequalities in the distribution of land and rural incomes from the Ottoman era and the colonial/mandate period. Reform broke up large holdings and distributed them to former peasants and share croppers but tribal control of rangelands, virtually "states-within-states", was also revoked in many countries. The unintended result of this was to take rangelands out of traditional common property management and move them to open access and subsequent uncontrolled use and heavy degradation.

Farmland taken from large landholders was often distributed among peasants in small, marginally economic units (Beaumont, 1989; Hopfinger, 1991). Land reforms in Syria have been followed by introduction of schools, electricity, clean water and all weather roads, resulting in enormous improvement in peasants' lives (Rabo, 1986).

Small and highly fragmented farms in Jordan and the need for soil and water conservation in rainfed areas that require modern equipment and proper management have led the agricultural sector away from the laissez-faire philosophy to land use characteristic of the Ottoman and post Ottoman periods. This philosophy resulted in land speculation, absentee landlords, share cropping on short leases without protection for tenants and ploughing of submarginal land with tractors. Pilot projects in Jordan have been based on the idea of government guided agriculture through legislation and compulsory farm associations or farm cooperatives for supply of credit and inputs and, with land pooling, for proper soil and water management and conservation where needed (Aresvik, 1976). It has been said:

"Some land reform programmes have given rise to the establishment of new rural institutions, of which the most important has been the government managed cooperative. These were intended to provide credit, the means for production and help with marketing. In many countries such co-operatives have not lived up to their expectations. Credit has been insufficient and machinery supply and maintenance a problem. Even more important, though, is the fact that farmers do not manage their lands individually. As a result, a feeling of alienation has occurred, with the co-operative officials viewed in much the same light as the landowners they replaced. In other cases state farms have been established in which members are paid either a fixed wage or in relation to the number of hours worked. With such organizations the workers do not feel a close tie with the land and so innovation and commitment have been lacking." (Beaumont, 1989)

Some policy issues needing consideration in respect of rehabilitation and sustainable productivity of rangelands are the appropriate form of institution and the length of tenure. Possibilities include government cooperative, tribal cooperative and private management and long term lease of state land or communal or private ownership with zoning or other restrictions on land use.

Determined efforts have been made to revive the communal 'hema' system of rangeland management in WANA (Draz, 1969). This ancient indigenous system provides reserve supplies of feed while protecting rangeland soils and vegetation (Masri, 1991; Qureshi, 1991). Unfortunately, "owing to the specific socio-economic and political changes of the past two decades in the Near East the idea of reviving the 'hema' system has not met with success" (Janzen, 1991).

The idea of communal land ownership and management seems foreign and unworkable to "westerners" living in societies ingrained with English Common Law. To them, individual responsibility, freehold ownership or contractual leases are the normal way of life. As experiences in Australia, the USA and Canada attest, there certainly can be problems with long term land degradation under their legal systems of land tenure and covenants.

The delineation of these problems in Australia and the unfinished debates on how best to solve them, have been well elaborated (Chisholm and Dumsday, 1987; Harrington *et al*, 1990) The possibility of communal ownership or leasing of farm or pasture land is never discussed in Australian debates but many of the points and proposals made, particularly for leased public lands, are worth considering in the context of institution building and revival in WANA. There are, however, enormous differences in human cultures and institutions. There are also profound differences in farm size and grazing management with typical Australian farms and flocks being perhaps 100 times larger than farms in WANA. Virtually all sheep grazing management in Australia is done inside boundary fences. Fences are unknown and shepherd grazing is the norm in WANA where farm wages are less than 10 per cent of those in Australia.

Several countries have attempted central planning and control of cropping patterns in their main farming areas, even going so far as to define the proportions of land in each district, and each farm in the district, which must be in which crops. Egypt and Algeria have recently abandoned this policy on grounds of economic efficiency. Among sources of efficiency are the new flexibility that farmers have to match production more closely to price signals and to resources, including their skills, family labour, soils and marketing and

employment opportunities.

Numerous studies on optimizing farm plans to maximize profits of crop/livestock enterprises under various prices and constraints have been conducted for specific sites in WANA. These include Turkey (Satana, 1974), Pakistan (Qureshi, 1975), Sudan (Abdelmagid, 1986; 1992; Shomo, 1992), Lebanon (Kizirian, 1970) and Syria (Sting, 1987; Maerz, 1990; Nordblom *et al*, 1992; Nasser, 1994). Further such studies by NARS will be needed to understand farmers' options under new technologies and new price sets.

Solutions to land use management problems in this region must come from within and be adapted to the conditions in each state.

Seed policy

Most formal plant breeding and conservation and characterization of genetic resources in WANA is done by government institutions with some help from the IARCs. The formal seed sector crosses, selects, tests, multiplies and distributes seed for farmers. Seed is expected to meet certain quality standards for purity and germination. It is through the plant breeding and selection process that high yielding varieties are introduced and germplasm shared among countries.

These services yield public goods, especially of self pollinating species such as wheat, rice, barley, lentils and chickpeas which can be multiplied many generations while retaining their genetic character and advantages. This makes such species unattractive for private breeding companies. Large state farms and public seed corporations in many countries that were established to multiply and distribute improved seed have, however, proved ineffective and failed to meet the diverse crop and varietal requirements of farmers (Jaffee and Srivastava, 1994).

The formal sector releases and multiplies named varieties of high genetic and physical purity. In the case of pasture species such as annual *Medicago*, however, a pure stand of a single variety is often not as desirable as a mix of species due to the ecological advantages of each species under different weather conditions. The formal seed sector could release pure lines to be blended later and sown as pasture mixes. This practice unfortunately further divides the small proportion of effort that NARS allocate to pasture and forage seed and multiplies the cost per species as well as reducing the volume of each species offered.

ICARDA and NARS are working to bypass this obstacle outside the formal sector in Algeria, Lebanon, Morocco and Syria. Local pasture species are multiplied and seed harvested by cheap hand sweepers (Christiansen, 1993). Seed pods of the pasture species are sown with a cereal crop. Some of the pasture plants germinate and form a pasture in the next year (Mitri, 1994). Pods can also be sown to rehabilitate non-arable pastures.

An open question for policy discussion is the desired balance in support for the formal and informal seed sectors in view of the fact that the latter is often larger and touches the greatest numbers of poor farmers. The question cannot easily be asked of the mass of farmers comprising the informal sector but NARS and IARCs would do well to seek answers through diagnostic studies in the neglected environments where farmers save their own seed.

Livestock policy

Public investments have tended to be heaviest in veterinary services because major public good can be derived through preventive measures. Veterinary epidemiology, research and extension have been identified as services yielding public goods whose provision is economically justified in most countries (Umali *et al*, 1994). Veterinary surveillance and quarantine can provide first line defence against introduction of infectious disease. Due, however, to the permeability of many national borders in the region surveillance and quarantine face great practical difficulties.

Governments can also effectively provide public goods through veterinary drug quality control and in food hygiene inspection especially in dairies and abattoirs to avoid moral hazards in these issues. Governments may also sometimes be justified in organizing vaccination campaigns, vector control and diagnostic support. Private goods with consumption externalities include clinical interventions such as diagnosis and treatment and preventive medicine including vaccination, vaccine production and vector control (Umali *et al*, 1994).

Emphasis and investment in veterinary services in many WANA countries appears greater than in some industrialized countries where livestock contribute a major share to the value of agricultural production. The extreme case is Egypt (Table 2) with one veterinary practitioner for each 431 Veterinary Livestock Units (VLUs). Only Japan in the developed world approaches this intensity. Iraq and Syria also have heavy veterinary cover. Jordan, Lebanon, Tunisia and Oman have about 4500 VLUs per veterinarian compared to 5000 in France. Morocco and Saudi Arabia in WANA proper have the highest ratios. Afghanistan, which can here be classed with the countries of South and East WANA has a ratio of over 20000 to 1 (Table 2).

Several countries forbid slaughter of young or productive female sheep. The practical result is that government abattoirs with inspection facilities mainly process male sheep whereas female sheep are slaughtered in the informal sector (Heylen, 1993). Carcasses without testicles intact cannot be hung on display by many butchers in WANA. The public health hazards of uninspected slaughter are the main problem where market forces quietly override a traditional regulation. Of equal importance, however, is that health inspection facilities are usually available only in the larger cities.

Table 2 Livestock economy and livestock health services in selected WANA and non-WANA developed countries

Country	Livestock share (%) of 1988 value		Veterinary Livestock Units ^a) in 1989 per		Ratio government: private veterinarians	
	Agriculture	GDP	Veterinarian	Trained auxiliary	1984	1989
Fast population growth: oil and remittance sensitive						
Afghanistan	41.6	-	24828	13659	-	9.4
Syria	33.9	8.1	1238	2804	-	0.3
Jordan	53.4	3.1	4786	18824	1.9	45.3
Transitional population growth: oil and remittance sensitive						
Egypt	26.5	6.2	431	642	31.7	8.6
Lebanon	38.9	-	4806	8278	1.3	0.6

Morocco	35.1	-	17082	4534	3.7	2.9
Tunisia	29.5	4.1	4499	5138	25.3	6.8
Turkey	22.7	5.2	6482	-	-	1.3
Oil exporters with large populations						
Algeria	41.5	1.7	7813	6105	309.0	8.0
Iraq	34.7	-	1126	1839	-	18.2
Oil exporters with small populations						
Libya	49.7	1.5	5256	2766	-	42.2
Oman	-	-	4840	3267	-	9.0
Saudi Arabia	54.1	1.1	16170	10054	-	-
South and East WANA						
Ethiopia	40.1	22.9	117754	24363	-	-
Sudan	58.3	21.2	34390	36852	-	-
Pakistan	41.7	14.9	20215	9241	-	-
Non-WANA industrialized countries						
Australia	6.4	3.4	8173	14691	0.2	0.2
France	51.6	1.9	5008	15468	0.1	0.1
Japan	54.1	0.3	569	-	-	0.6
United Kingdom	63.8	1.2	2489	7673	0.1	0.1
USA	46.7	1.3	2912	5660	0.1	0.1

Note:

a) Veterinary Livestock Unit calculated as 1 cow/camel, 2 horses/donkeys, 10 sheep/goats, 100 fowl (these differ from Tropical Livestock Units)

Source: Umali *et al*, 1994 drawing on various other sources

A further regulation in the main rainfed districts of northern Syria and northern Iraq requires all sheep flocks to move out of the area from mid February until after harvest of the crop. Flocks are allowed to graze weeds and young cereal crops in winter but must be removed later due to the impossibility of preventing night grazing of crops by flock owners. Such regulations are in direct conflict with efforts at better integration of livestock and crop production using sown pastures grown in rotation with cereals.

Veterinary and auxiliary staff numbers do not always translate into services. Compared to their counterparts in developed countries veterinary personnel in WANA often lack equipment, are underpaid and do not have access to transport or communications. Migratory flocks and herds add to the challenge faced by the veterinary services.

Health and productivity are closely linked to nutrition and management. Research and extension on nutrition and management have received lower priority than they deserve in most WANA countries and usually trail behind veterinary services and efforts at genetic improvement. With "public good" justification most WANA countries have embarked on expensive and ineffective breed improvement programmes. Livestock nutrition and management often remain "traditional" and are considered something that farmers already know everything about, thus justifying research neglect.

Vitamin or trace mineral deficiencies in feeds offer the prospect of high economic response through better livestock performance. Sheep are known to be deficient in sodium and vitamin E across wide areas of Jordan, Syria and Turkey, suffer from copper deficiency in the Euphrates valley in Syria, are deficient in selenium in Turkey and are low in zinc in many WANA countries (White, 1994). Supplementary feeding of trace elements and minerals, which is common in the developed countries, remains virtually unknown in WANA.

Use of near infra-red spectroscopy techniques on small samples of straw linked to voluntary intake of the same straw by sheep provides the possibility of inexpensive early screening for quality in plant breeding programmes (El-Haramein and Goodchild, 1993). More efficient integration of livestock nutrition and better cereal/legume crop rotations offer the prospect of more profitable and stable rainfed farming systems (Nordblom *et al*, 1994).

The open policy question to be faced by NARS and IARCs is the optimal balance of emphasis on veterinary services, animal genetic improvement or better nutrition and management. The last are closely linked to or part of crop and resource management because animal nutrition encompasses crop residues and forage crops, grazing of native pastures and feed grains and feeding of concentrates.

Crop residues and rangeland production are marketable only via livestock. Poor productivity by WANA livestock is linked to poor management on the farm and indigenous livestock often perform well below their genetic potential. In these conditions veterinary services and breed improvement cannot overcome the effects of poor nutrition and management. There is still little quantitative data but considerable work is needed simply to approach the policy question of balances between veterinary, breeding and management work on livestock and the broader balance between crop and livestock research.

Some WANA countries open or close their borders to imports and exports of live animals with sometimes disturbing consequences for their own and their neighbours' enterprises. Some also try to prevent (or require) internal movement of livestock and other commodities among their own provinces.

Egypt and Syria have feed subsidies, credit for sheep fattening cooperatives and systems of feed delivery and storage in the dry rangelands. They have also renovated Roman cisterns for stock water. These measures have contributed to overstocking of rangelands in both countries.

Livestock market information and well differentiated price signals to producers are often poor or totally lacking (Rodríguez *et al*, 1993). Information is typically limited to verbal contacts and personal observation in local livestock markets where animals are sold at a negotiated price either singly or in lots with condition and weight being judged by feel and sight. Public market transactions lower

costs for buyers and sellers and limit the scope for misinformation. Good road and telephone links further serve these purposes as do quality standards or grades for live animals or carcasses. These, however, are usually missing. Government imposed regulations are often intended and used to keep urban retail meat prices down (Mahmood and Rodríguez, 1993). It is not always possible to enforce these regulations and they may, in any case, have negative consequences on both producers and consumers.

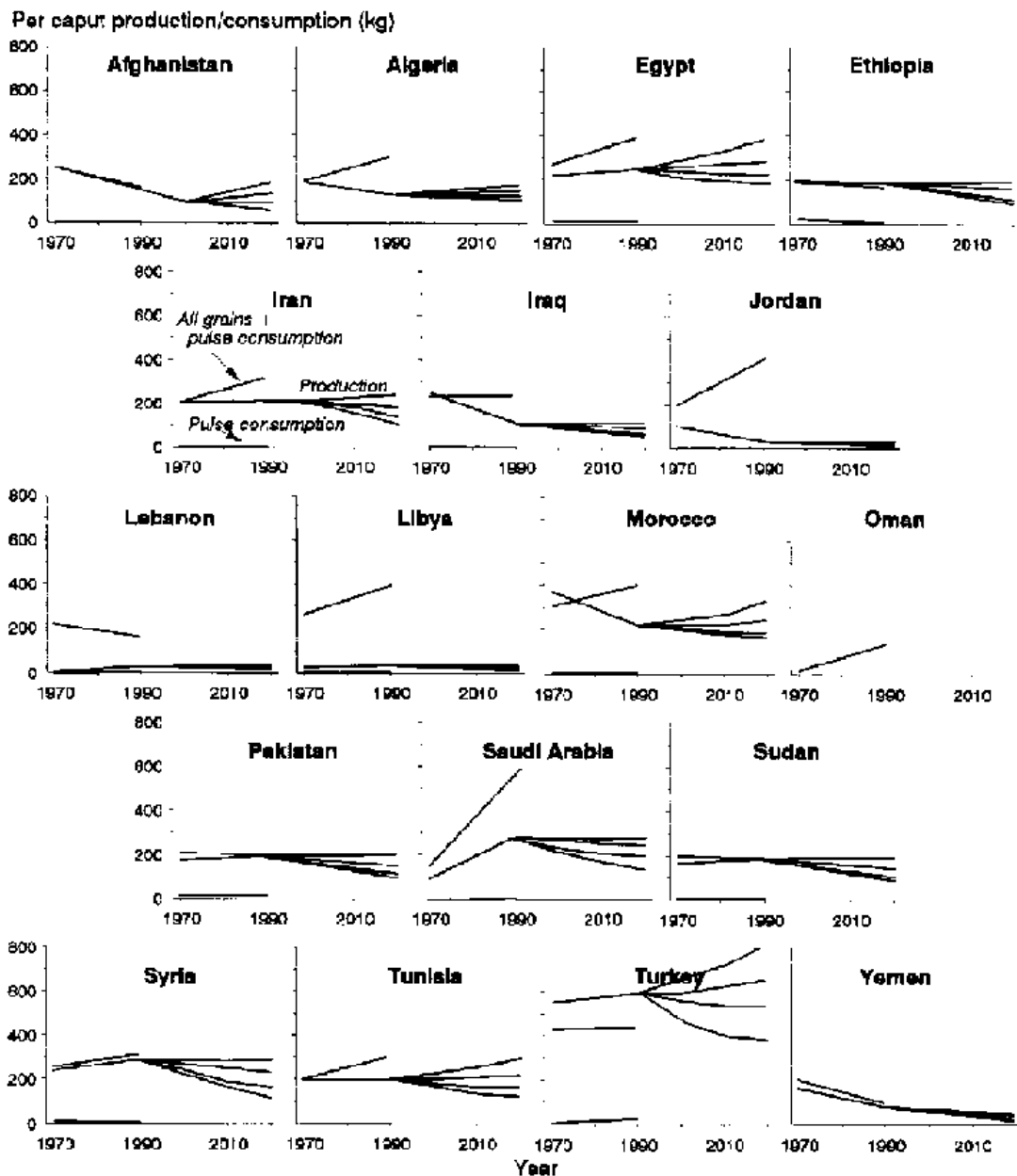
Macromixes: projections to 2020

Grain production and consumption

Reviews of grain production and consumption from 1970 to 1990 and projections to 2020 reveal large differences among countries in the range of plausible outcomes (Nordblom and Shomo, 1994). Population and production data from standard sources (FAO, 1993a: USDA, 1994) for two 5-year periods centred on 1970 and 1990 for 18 countries were plotted as 20-year trend lines (Figure 3). Consumption patterns (for both livestock feed and direct human consumption) were also calculated for these periods. Grain use in Jordan, Libya and Saudi Arabia rose very rapidly from 1970 to 1990. Much of the increase was for livestock production as reflected in changes in human diet composition (c.f. Figure 1). Livestock production is chiefly for domestic use in Saudi Arabia and Libya. Syrian and Jordanian merchants and farmers' cooperatives import live animals, grow and fatten them with domestic and imported feed and re-export them to the Gulf states. The poorest countries have not been able to balance population growth with increased production or imports and human diets have declined in quantity. These countries have all suffered civil wars and major economic dislocations. Production in Tunisia, Egypt and Syria has kept pace with population growth while in Morocco it has not. Income growth and concessionary pricing has enabled the import of grains for food but also as poultry and livestock feeds. Demand for grain was greatly in excess of production in Jordan, Libya and Saudi Arabia.

Turkey is the greatest agricultural country of the region and its per caput production is nearly double that of its nearest contenders. Turkey is unique for having promoted a large, sustainable and economically sound agricultural sector and is further developing its substantial renewable water sources for irrigation. Turkey is, and will probably remain, WANA's largest (if not only) net exporter of cereal grains and pulses.

Figure 3 Cereal grain plus pulse consumption and production from 1970 to 1990 and projected production of all grains to 2020 (production trend projected at annual rates of increase of 3 per cent (outstanding), 2 per cent (excellent), 1 per cent (good) and 0 per cent)



Algeria has a substantial agricultural sector producing below its capacity. It imports most of its total grain consumption and funds this by oil exports. Like the other "oil-exporters with large populations" Algeria has given highest priority to industrial development and neglected, in relative terms, rural development and agriculture (EIU, 1992). This group of countries is considered to have, in addition to oil, good physical potential for sustained agricultural growth (Janssen, 1993).

Jordan, Libya and Oman produce the smallest shares of their own consumption and import most of what they use. Changes in levels of domestic production would have negligible impact on human diets. This fact may ultimately limit popular support for major uneconomic investments in increasing grain production instead of pursuing other opportunities such as intensive production of higher value crops.

Saudi Arabia has developed substantial grain production capacity based on irrigation with nonrenewable water supplies and heavy fertilizer use. This is a unique achievement in the region although Libya is proceeding with its "Great Man Made River" project (EIU, 1992). Costs of production in Saudi Arabia are, however, several times higher than world prices even without accounting for the scarcity price of water or costs of subsidies on investments in irrigation (Nurul Islam, pers. comm.)

Opportunities for expanding rainfed or irrigated areas in WANA are few (Alexandratos, 1988). It is in this context that sustainable increases in rainfed agricultural productivity of grain, pasture, forage and livestock are the key focus of ICARDA.

The role of pulses in human diets is greater than their small quantities suggest (Figure 3) due to their high protein and energy contents and their use in diets of the poor as substitutes for animal products (Oram and Belaid, 1990). The faba bean, for example, is known as the "poor man's meat" and lentils and chickpeas are known to have similar nutritive qualities.

Per caput consumption is not projected beyond 1990. An imaginary flat line of constant 1990 per caput consumption (Figure 3) shows the gap with production under the various assumptions. Increases in per caput consumption over 1990 levels are badly needed in the poorest countries. Consumption per caput is unfortunately not a function of want but of effective demand and is directly related to income level. Per caput consumption can be expected to rise to 400 kg or more per year in countries with moderate incomes. Any gap between production and consumption in these countries will be made up by grain imports which in many cases will

consist of feed grains.

Current levels of production of all grains can be maintained in most countries although, as in Saudi Arabia, it will not always be economic. Continued efforts will, however, be needed to keep inputs in the form of improved seeds, fertilizers and fuels flowing and for maintaining infrastructure. Attempts to increase production by varying proportions (Figure 3) would require greater effort and technical, economic and political help. High anticipated costs for sustaining very rapid production increases must be balanced against the low costs of imported grain.

Optimization of future national grain production trajectories involves economic analyses of comparative advantages and the taking into account of other sectors, domestic resources and world prices. There is also a large element of political choice capable of ignoring or embracing such arguments.

These analyses are beyond the scope of this paper and no comment is made on the current capabilities for enlightened political choice in the countries of the region. In principle, however, each country should seek out its comparative advantages and may wish to improve them through investments in human capital and infrastructure.

The range of possibilities for economically viable rates of increase in grain production could run to more than five per cent in countries where agriculture has been neglected in favour of industrial growth and where there is still considerable potential for intensification, as in Morocco, Algeria and Iraq. In Iraq, for example, cereal (mainly wheat and barley) areas increased by 100 per cent from 1989 to 1990 and production increased by 130 per cent. Production was down by 21 per cent in 1991, however, due to policy changes, changed incentives for farmers and the weather (USDA, 1993b).

Irrigated cereal production by oil exporting countries with small populations could be reduced by 10 per cent or more annually if they choose to restrict allocation of non-renewable water supplies to high value vegetable crops and domestic uses. They could then buy the needed food and feed grains on the world market and maintain strategic food stocks as appropriate.

Other countries in the region do not have such options and the range for manoeuvre is more restricted. The poorest countries could increase production at more than three per cent annually under peaceful conditions following civil war. Such "peace dividends" are not automatic, however, and depend on wise policy and investments.

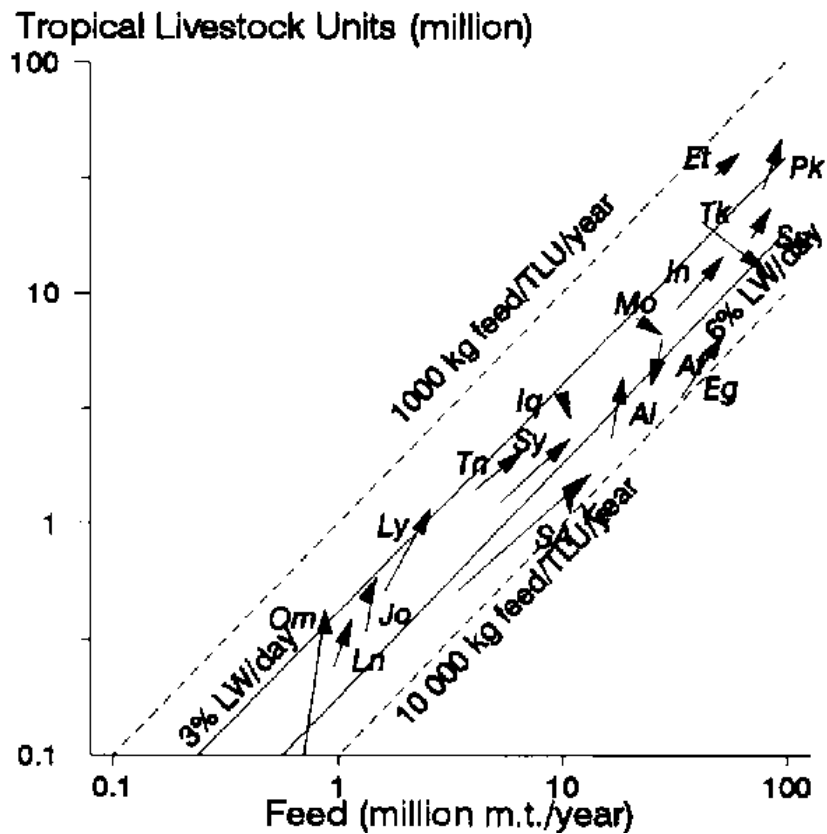
The effects of failure to achieve higher production in the face of population increase cannot be quantified in terms of human misery. High population growth rates drag down per caput projections of grain production in most countries. The more "downward-bending" the production projections the higher the projected rates of population growth (Figure 3).

Livestock and feed

Livestock include ruminants for meat and milk, camels and equines for draught and poultry (chickens and turkeys) for eggs and meat (Appendix Table A). Poultry products are gaining importance and account for a major share of animal products in human diets in many countries (USDA, 1993a).

Aggregation of animal populations for each country was done by taking the numbers of each kind and multiplying by a factor for conversion to a Tropical Livestock Unit (TLU) equivalent to a bovine of 250 kg live weight at maintenance. The aggregate TLUs were then plotted against total livestock feed (Figure 4). Feeds include crop residues of all sorts, grazing from native pastures, feed grains and other concentrates (Appendix Table B).

Figure 4 Numbers of Tropical Livestock Units and availability of all feeds in selected WANA countries (arrows are 20-year trends of 5-year averages centred on 1970 and 1990)



Crop residues are not usually reported in national or international statistical series but quantitative estimates can be derived with some confidence by using relevant crop data and multiplying by a factor specific to each (Appendix Table B).

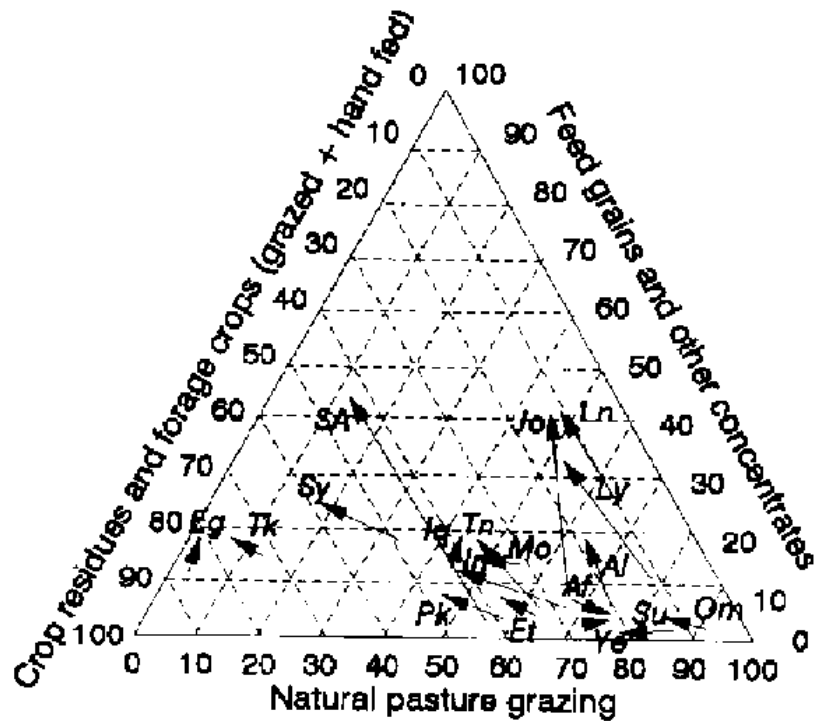
Native pasture or rangeland grazing is the most important feed source for several countries (FAO, 1993a). Offtake quotients are not reported in any regular statistical series but was estimated for 10 countries by multiplying areas by specific assumptions (Appendix Table B).

Feed grains and other concentrates include domestic and imported barley, maize and cottonseed (whole, meal and cake). They are the smallest feed category for most countries in WANA but exceptions are Saudi Arabia, Jordan and Libya (Figure 3) where spectacular increases in feed imports have occurred over the past 20 years.

The mega-trend chart (Figure 4) illustrates the close match between aggregate TLUs and total feed availability in WANA. The envelope of annual dry matter consumption, which assumes feeding levels between three per cent and six per cent of live weight per day, covers the middle range of the region's feed and livestock balances. The three feed categories of crop residues and forage crops, natural pasture grazing, and feed grains and other concentrates, nominally add up to 100 per cent of feed use. Contrasts in feed resource endowments and general shifts towards greater proportions of feed grains and crop residues and away from natural grazing are apparent most spectacularly in Jordan, Lebanon,

Libya and Saudi Arabia (Figure 5). All countries except Afghanistan and Yemen show natural pastures as diminishing proportions of livestock diets. This trend does not take account of rangeland degradation for which there are no quantitative data but is the outcome of increased livestock numbers, increased cropping activities and more use of feed grains.

Figure 5 Livestock diet composition by feed category for selected WANA countries (arrows are 20-year trends of 5-year averages centred on 1970 and 1990)



The general trend towards greater use of feed grains and concentrates is expected to continue. Much of this will be to supplement diets based primarily on crop residues and natural grazing but increasing amounts will be profitably used in expanded feeding operations for dairy, poultry and meat production (Khalidi, 1984; Sarma, 1986).

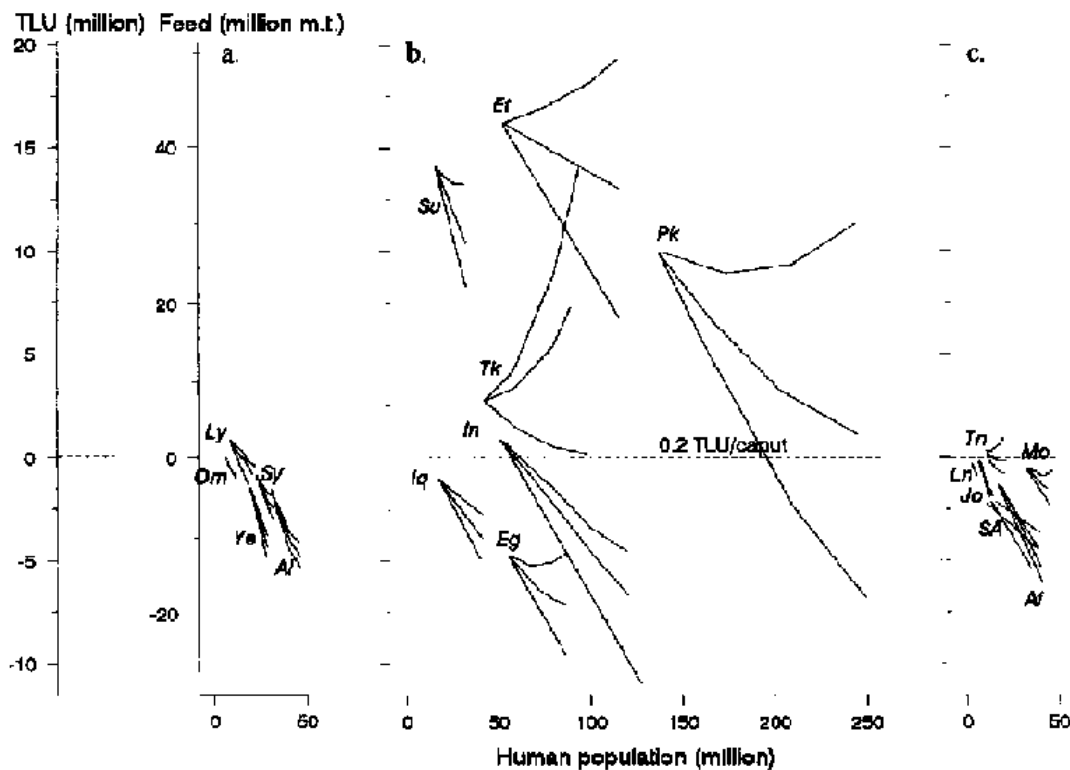
Domestic feed production in most WANA countries will probably increase with developments in crop and sown pasture production. Quantities of both domestic crop residues and feed grains should increase and there should be better management of cereal crops in rotations including forage and food legume crops (Osman *et al*, 1990). In spite of this, domestic feed production is unlikely to keep up with demand in most countries.

Feed deficits

If it is assumed that crop production increases are allied to increases in crop residues, forage crops and feed grain production in equivalent proportions it is possible to make projections of the numbers of TLUs that can be supported by domestic feed sources in the future. The analysis further assumes, somewhat optimistically, that natural grazing sources will continue to provide current levels of feed. Subtracting feed imports from each country's total feed resources gives a median estimate of 0.2 TLU per caput for 1990 (Nordblom and Shomo, 1993).

Owing to abundant domestic crop residue and rangeland feed resources some countries show surpluses well above 0.2 TLU per caput (Figure 6). The TLU figures represent, however, the standing populations of livestock and not the annual offtake of livestock products. A deficit in TLUs may be satisfied either by imports of livestock products or imports of feeds at the rate of 2738 kg dry matter per TLU but such deficits may simply remain unsatisfied. Libya is projected to have a feed deficit of under one million tonnes by 2020 if the country's crop production increases at an annual rate of three per cent and a deficit of about 2.5 million tonnes at one per cent whereas Syria's and Algeria's larger populations, with feed deficits already apparent in 1990, are projected to have very large deficits by 2020 (Figure 6a). Scenarios of one per cent rates of increase in crop production would leave some countries with large deficits in domestic feeds given their projected populations (Figure 6b, Figure 6c).

Figure 6 Projected surpluses and deficits in Tropical Livestock Units and livestock feed assuming constant demand of 0.2 TLU per caput (lines begin with a node at 1990 and branches spread to nodes for 2000, 2010 and 2020 for 1 per cent, 2 per cent and 3 per cent rates of increased crop production)



It is most likely that oil rich countries such as Libya, Saudi Arabia and the Gulf states will buy more live stock products and feeds as their populations grow. Poorer countries with the majority of WANA's population will have access to ever smaller amounts of animal protein per caput beginning from an already low base (c.f. Figure 1). Pulses, which substitute for livestock products at lower incomes, will probably gain in importance in absolute terms. Even substantial increases of three per cent per annum will not reduce the decline in per caput TLUs capable of being supported by domestic feed production in most countries of the region.

Macro conclusions

"Oil exporters with small populations" must be considered separately from other countries of the region based not only on their oil wealth but also on poor prospects for economically sustainable large scale agriculture. If, as is done elsewhere (Alexandratos, 1993; Mitchell and Ingco, 1993; Rosegrant and Agcaoili, 1994), these countries are included in overall analyses the prospects for food purchase of "food-deficit WANA" are overstated.

"Oil exporters with large populations" are another matter in terms of agricultural potential and the financial resources to develop them. They form a subgroup which should be distinguished from the rest of the region. Each country in this group is projected to have annual feed deficits of some 10 million tonnes by 2020. The combined (and rapidly growing) population of 101 million means that these countries deserve special attention.

The "oil and remittance sensitive countries" are at various levels of development but rely on rainfed agriculture and pastures for much of their production. With the exception of Turkey, and possibly Tunisia, countries in this group will all face food and feed deficits by 2020.

Egypt and Pakistan each have large populations, agriculture that is heavily dependent on rivers (although there is some rainfed farming) and extensive dry rangelands. Both countries deserve separate attention and Egypt in particular has the current largest feed deficit in WANA. Turkey should also be considered separately and not aggregated with the rest of WANA because its good soil and water resources otherwise mask the conditions of the poorer countries. Turkey and Tunisia are the only countries in WANA proper projected to support more than 0.2 TLU per caput in 2020. Other analyses (Alexandratos, 1988; 1993; Mitchell and Ingco, 1993; Rosegrant and Agcaoili, 1994) do not treat Turkey separately and therefore overstate the agricultural capacity of the "food-deficit states".

The problems in WANA agriculture cannot be solved by averaging the poor with the rich on paper but by raising the capacities of the poor. A perceptive person recently remarked: "The WANA region has a glorious past, a worrying present and a frightening future". Perhaps the "fright" comes with the realization that food self sufficiency is not attainable for most WANA countries in view of their enormous population increases. Food demand has outgrown domestic production in most countries and will probably continue to do so.

Greater integration with world markets will become more essential as will investments in human capital, research and technology development. Each WANA country will benefit by developing its agriculture in a manner consistent with its particular comparative advantages. Being a large importer of food and feed grains is not a catastrophe provided a country develops stable means of financing imports through service industries, manufacturing and advantageous nonagricultural and agricultural exports. Where these means are not actively developed serious food crises can be expected in the future.

In respect of comparative advantages in meeting livestock/feed deficits by importing feed, an alternative is to import live animals and frozen or processed livestock products. Policies favouring feed and livestock product imports at prices below domestic production costs could benefit consumer diets but damage domestic livestock and feed producers. In some cases this could have favourable environmental impact, through lower price incentives and by discouraging risky cereal cultivation and overgrazing in the rangelands. This, and the obvious prospects of a rising import market for low cost feed grain and livestock products, should attract the interest of

the major feed and livestock exporting countries.

Public goods will be needed over the next 20 years to improve human welfare and sustain natural resources. Public goods resulting from international research but for which full funding from national or private sources cannot be justified or expected include:

- human capital and institutional strengthening in rangeland tenure and the making of decisions at the farm level (pastoralists and farmers with insecure tenure cannot be expected to consider sustainable resource use but major economic gains appear feasible by devolving property rights and decision making from state bodies to individual farmers or well organized small groups);
- evaluation, conservation and improvement of plant (particularly wheat, barley, lentils, chickpeas, faba bean, forage crops and pasture species whose centres of origin and wild relatives are in WANA) and animal genetic resources (for example, the hardy fat tailed sheep found from Tunisia through central Asia and prized for milk and meat production) by international institutions working in partnership with NARS;
- helping the informal seed sector to provide improved services by support for strategic research on methods followed by well informed extension; and
- giving increased attention to improving livestock management and nutrition on the farm and encouraging economic balance with the current emphasis on national veterinary and animal breeding investments in WANA.

It is no coincidence that ICARDA's mandate is focused on the strategic research areas designed to yield public goods information and the building of human capital for the sustained benefit of mankind. Partnerships with NARS are as much a key as are concerns for sustaining natural resource use and the welfare of resource users and consumers. Partnerships with other CGIAR centres and non-CG centres of excellence will be essential to bring resources and critical masses of research skill to bear on many of these issues.

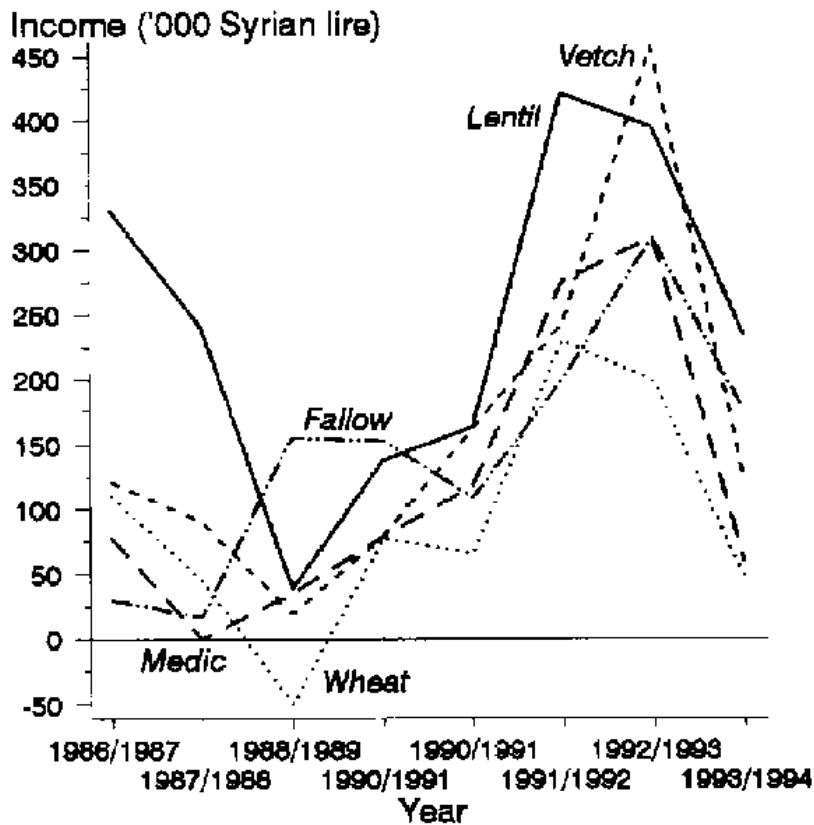
Micromixes: projections to 2020

Feeding/grazing calendars in mixed systems

System specific feeding and grazing calendars for sedentary farmers in northeast Syria, agropastoralists in northwest Syria and sedentary (semi-intensive sheep/cereal) farmers and pastoral (goat) herders in the Bekaa Valley of Lebanon are presented here (Goodchild *et al*, 1995). Northeast Syria is a semiarid rainfed crop zone with about 400 mm mean annual precipitation but where there is also some irrigated cotton (Nordblom *et al*, 1993a). The northwest Syria study focuses on flocks with winter bases in rangeland-barley areas with about 230 mm mean annual precipitation that move in summer and autumn to graze crop residues in higher rainfall and irrigated areas (Wachholtz *et al*, 1993). Pastoral goat flocks in Lebanon typically graze foothills and rangelands in spring, summer and autumn whereas sheep of the sedentary farmers stay on or near their home farms the whole year (Hamadeh *et al*, 1994).

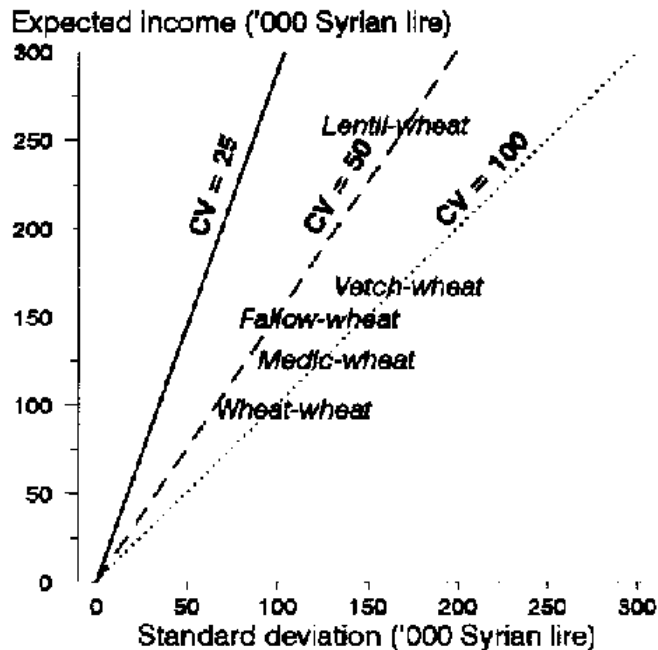
Feed calendars were developed (Figure 7) based on a single round survey of more than 30 farmers in each system (Nordblom *et al*, 1993b). Characteristics common to all systems are the marked seasonal diversity in feed sources, hand feeding of cereal straw and concentrates in the winter and stubble grazing in summer. There are differences, however, in the importance of range grazing and in the starting and ending dates and importance of this feed source. Access to various crop residues, feed grains and agro-industrial by-products such as sugar beet pulp, wheat bran and cottonseed cake is also reflected in the differences in diets among the four systems.

Figure 7 Composition of small ruminant diets as reported by farmers in single round surveys in a. northeast Syria, b. northwest Syria, c. a semi-intensive system in Lebanon, and d. a pastoral system in Lebanon (one symbol, 4 per cent of diet; upper case symbol, hand feeding; lower case symbol, grazing; C, cereal straw; L, legume straw; E, energy feeds; P, protein supplements; s, cereal stubble; r, higher nitrogen crop residues; u, unharvested crops; g, pasture and range grazing)



The model results are best viewed as expected means and variances of net whole-farm income over time (Figure 9). Standard deviations and coefficients of variation (CV) are used as measures of income variation to allow easy comparison among rotations. Lentil-wheat, for example, offers not only the highest mean but the lowest CV in whole-farm incomes and there is little doubt why this rotation is the most common in the area. Wheat-wheat and wheat-medic, in contrast, provide the lowest means and highest CVs. Fallows and vetch are not widely used in the study area and medic remains virtually unknown to farmers except as a local weed.

Figure 9 Mean and standard deviation of whole-farm income for a 16 ha farm for crop rotations with wheat (Kamishly area, northeast Syria)



Continuous wheat-wheat has been required by government regulations in recent years in order to maximize production of this strategic crop. The resulting low yields and incomes have now been recognized and the regulations rescinded.

Similar results were obtained with a model based on price and growing conditions for a slightly lower rainfall zone (330 mm) in northwest Syria over the period 1985-1993 (Nordblom *et al*, 1995). Crop and pasture offtake estimates are from a large crop rotation and grazing trial at ICARDA's main station, 35 km south of Aleppo. Farm and market surveys in the area provided the economic data.

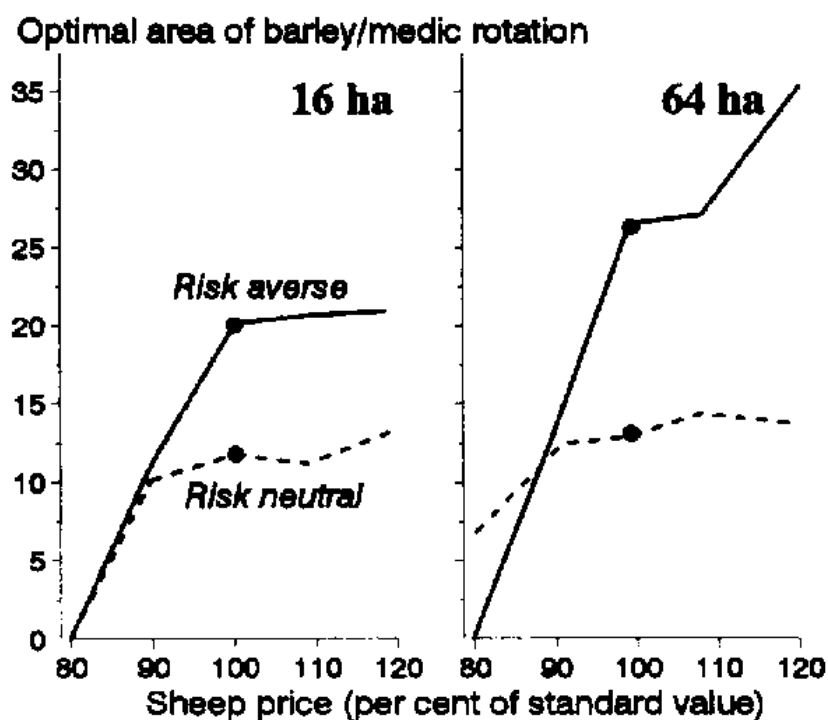
Farms with 16 ha and 64 ha of arable land are considered as typical and large farms in this area. Barley yielded better than wheat after medic because it matures earlier. Barley prices are always lower than wheat but medic-barley is an additional rotation option in northwest Syria. The lentil-wheat rotation was again best in this model as it was in northeast Syria. With the model set to find an optimal mix of rotations barley-medic entered the farm plan at low but significant levels with the major proportion of the farm going to lentil-wheat. This is explained by a low correlation between lentil yields and medic pasture offtake such that the combined potential for economic crop and feed production is better than either rotation used alone.

All model runs were made with the "standard" set of prices and yields observed over the 8-year study period and the effects on the medic/barley area of changes in prices of sheep were considered for risk averse and profit maximizing (risk neutral) farmers.

Price levels were set at 80, 90, 100, 110 and 120 per cent of the standard and a sensitivity analysis was done representing the outcome of 40 runs plotting only the "highest-utility" results among 20 runs with sheep and 20 without (Figure 10). The no sheep option removes the labour needed for herding. At the 100 per cent cost/price condition the risk averse solutions for both 16 ha and 64 ha farms call for greater areas of barley/medic pasture than the risk neutral solutions. In addition, and for both risk levels, barley/medic takes a larger share of crop land of the 64 ha than of the 16 ha farm. This can be explained by the relative shortage of family labour on the larger farm linked with the low labour demand of medic compared to lentils.

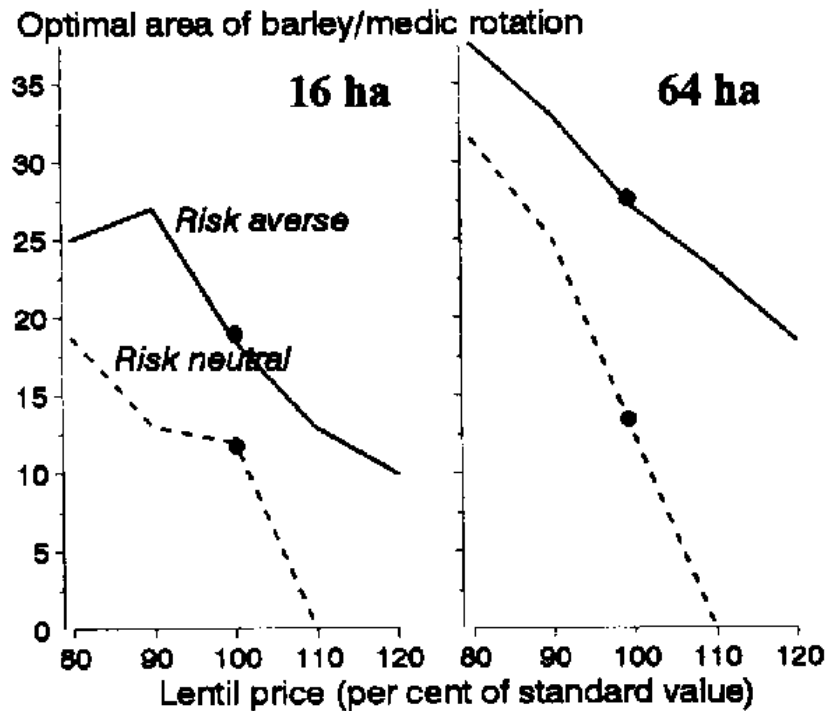
Reduced or increased sheep prices relative to the standard 100 per cent (Figure 10) call for corresponding decreases or increases in the optimal barley/medic pasture area on both farm sizes if the farmer is risk averse. With sheep prices at 80 per cent of standard, *ceteris paribus* a no sheep-no medic strategy would be best for risk averse farmers on both large and small farms. With sheep prices at 120 per cent of standard nearly a quarter of the area of small farms and a third of large farms would be devoted to the barley/medic rotation. The effects of different sheep prices are less pronounced for risk neutral farmers.

Figure 10 Optimal (per cent of total) of barley/medic rotation on "typical " 16 ha and large 64 ha farms at variable sheep prices in northwest Syria



The effects are dramatic if lentil prices are allowed to oscillate around the standard level, (Figure 11). As lentil/wheat in the rotation is the strongest competitor for land with barley/medic, higher lentil prices lead to an increase in the share of lentils in the farmer's portfolio of rotations. Lower lentil prices, on the other hand, open the way for greater allocations to barley/medic.

Figure 11 Optimal area (per cent of total) of barley/medic rotation on "typical " 16 ha and large 64 ha farms at variable lentil prices in northwest Syria



Effects of access to rangeland on interest in medic pasture

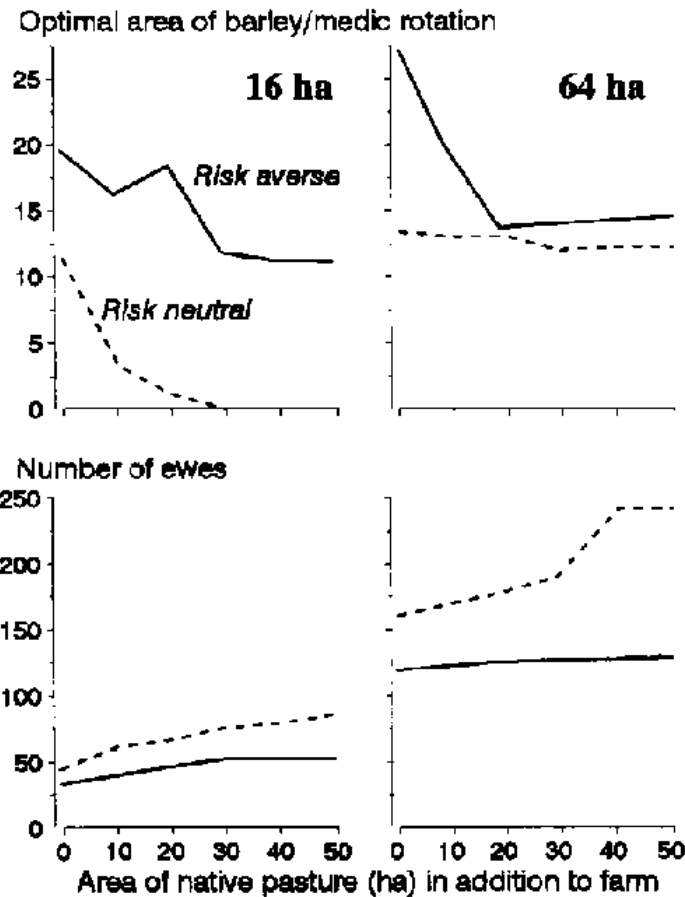
The adaptability of sheep to various diets and the ability of shepherds to direct them to the cheapest available feed source in a given season and year have so far been reflected in the model on the assumption that sheep must stay on the farm. Many farmers, however, have access to grazing off the farm, including rangelands and roadsides. The use of such areas is typically heavy and persistent by multiowner flocks often under open access conditions but sometimes under common access by a closed group to a village or cooperative grazing area. Exclusive use of a range grazing area by a single farmer is very rare in Syria (Nordblom, 1993).

The grazing offtake potential from a given area of rangeland and yields of rainfed crops vary from year to year depending on the weather. Rangeland offtake in the study area, derived from a long term grazing trial, is estimated at 50 per cent of biomass production (Osman *et al*, 1991; Osman, 1992; Osman and Bahady, 1993). It can also be assumed (Nordblom and Thomson, 1987) that rangeland can be grazed in winter and/or spring. Taking all winter grazing would preclude spring grazing, and vice versa. Linear combinations of the options are available each year (Nordblom *et al*, 1995). Costs associated with the rangeland in addition to herding, are assumed to include an annual maintenance application of triple superphosphate fertilizer similar to that under which the trial observations were made.

The assumption limiting range grazing to the winter and spring months (January-May) is justified by results of surveys of flock owners in northern Syria in which rangeland use was reported to be negligible at other times mainly due to the seasonal availability of other feeds and especially cereal stubbles and straws (Nordblom, 1987; Wachholtz *et al*, 1993).

Model runs showed consistent results for both farm sizes and both levels of risk in that exclusive access to 10 ha of rangeland led to lower strategically optimal areas of barley/medic and larger flock sizes (Figure 12). Another consistent result was that risk averse farmers of either farm size would prefer smaller flocks and larger barley/medic areas than those chosen by risk neutral farmers regardless of the area of rangeland up to 50 ha. With 30 ha of rangeland the risk neutral farmer with 16 ha of farmland would drop barley/medic from the optimal portfolio while maintaining a substantial flock size.

Figure 12 Optimal area (per cent of total) of barley/medic rotation and sheep flock size on "typical" 16 ha and large 64 ha farms with exclusive access to additional areas of range grazing in northwest Syria



Due to substitution of cheap range grazing for relatively expensive medic pasture (opportunity costs of not growing higher value wheat crops) greater access to rangeland means lowered interest in medic pasture. In the major farming districts, however, many farmers have little, and very rarely exclusive, access to substantial areas of rangeland.

The implications of access to rangeland on choice of farming activities have not yet been fully explored but these results provide new insights. The income generating capacity added to a rainfed farm by well defined access to rangeland raises the question of economic incentives for maintaining and increasing range production through better management. This is likely to be a key to supporting institutional reforms for rangeland property rights.

The analysis reveals a positive but limited economic niche for medic pastures in northwest Syria. The size of this niche is sensitive to a number of variables such as sheep and lentil prices, farm size and access to rangeland. Prices are subject to change as the economy develops in relation to world markets. Current tariff protection of domestic sheep and lentil prices, for example, provides plus and minus incentives for medic pasture.

Micro conclusions

The clear lesson to be drawn from the micro-analyses of the diet calendars and whole-farm models in the light of the macroanalysis which demonstrates vast differences in national feed resources among countries is that different farming systems with different optimal mixes of crop and livestock activities will be found across the region. From the farmers' viewpoint optimal mixes of activities will shift with changing prices of inputs and outputs as well as with changes in technology or policy that alter production possibilities. Both technology and policy are susceptible to improvement for more sustainable and productive mixed farming systems in WANA. This provides some relief to the region's rather gloomy prospects for rapidly declining self sufficiency in livestock production in view of the expected large increases in human populations to 2020 and beyond.

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Appendix Table A Trends in livestock numbers (millions) in WANA, 1968-1972 to 1988-1992

Country	Year	Livestock species									Total (TLU)
		Sheep	Goat	Cattle	Buffalo	Camel	Horse	Donkey	Mule	Poultry	
Fast population growth: oil and remittance sensitive											
Yemen	1968-1972	1.9	2.3	0.8	0.0	0.2	0.0	0.6	0.00	3.0	1.5
	1988-1992	3.1	2.8	0.1	0.0	0.1	0.0	0.6	0.00	21.0	1.3
Afghanistan	1968-1972	16.4	2.4	3.0	0.0	0.3	0.3	1.1	0.03	6.0	5.1
	1988-1992	10.8	1.8	1.4	0.0	0.2	0.3	0.1	0.03	6.0	2.8
Syria	1968-1972	4.8	0.6	0.4	0.0	0.0	0.1	0.2	0.05	4.0	1.1
	1968-1972	12.2	0.8	0.6	0.0	0.0	0.0	0.1	0.05	12.0	2.0
Jordan	1968-1972	0.6	0.3	0.0	0.0	0.0	0.0	0.0	0.01	10.0	0.3
	1988-1992	1.3	0.4	0.0	0.0	0.0	0.0	0.0	0.01	40.0	0.6
Transitional population growth: oil and remittance sensitive											
Egypt	1968-1972	1.7	1.0	0.1	1.7	0.1	0.0	1.1	0.01	25.0	3.0
	1988-1992	3.5	3.6	2.3	2.3	0.2	0.0	1.2	0.00	36.0	5.7
Lebanon	1968-1972	0.2	0.3	0.1	0.0	0.0	0.0	0.0	0.01	5.0	0.2
	1988-1992	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.01	18.0	0.3
Morocco	1968-1972	13.8	6.9	2.9	0.0	0.2	0.3	0.8	0.32	13.0	5.3
	1968-1972	12.2	4.4	2.8	0.0	0.0	0.2	0.8	0.43	33.0	4.8
Tunisia	1968-1972	4.2	0.6	0.6	0.0	0.2	0.1	0.1	0.10	7.0	1.3
	1988-1992	5.0	1.0	0.5	0.0	0.2	0.0	0.2	0.10	33.0	1.7
Turkey	1968-1972	30.4	16.7	11.1	1.0	0.0	0.9	1.6	0.24	30.0	15.5
	1988-1992	35.6	9.9	10.1	0.4	0.0	0.5	0.9	0.17	74.0	13.7
Oil exporters with large populations											
Algeria	1968-1972	8.8	2.1	0.7	0.0	0.1	0.1	0.3	0.15	12.0	2.2
	1968-1972	14.8	2.0	1.2	0.0	0.1	0.1	0.3	0.09	61.0	3.5
Iran	1968-1972	24.7	11.3	4.7	0.2	0.1	0.3	1.7	0.12	46.0	8.8
	1988-1992	36.7	19.9	5.9	0.3	0.1	0.2	1.6	0.11	137.0	12.6
Iraq	1968-1972	10.3	1.9	1.5	0.2	0.2	0.1	0.5	0.05	9.0	3.1
	1988-1992	7.5	1.3	1.3	0.1	0.0	0.0	0.3	0.02	48.0	2.6
Oil exporters with small populations											
Libya	1968-1972	1.7	1.0	0.1	0.0	0.1	0.0	0.1	0.00	1.0	0.5
	1968-1972	4.3	0.9	0.1	0.0	0.1	0.0	0.1	0.00	43.0	1.2
Oman	1968-1972	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.00	1.0	0.1
	1988-1992	0.1	0.6	0.1	0.0	0.1	0.0	0.0	0.00	2.0	0.3
Saudi Arabia	1968-1972	1.5	0.6	0.1	0.0	0.1	0.0	0.1	0.00	3.0	0.5
	1988-1992	5.1	2.7	0.2	0.0	0.3	0.0	0.1	0.01	63.0	1.9
South and East WANA											
Ethiopia	1968-1972	20.0	14.6	21.9	0.0	0.8	1.2	3.2	1.17	40.0	23.3
	1968-1972	19.5	14.9	24.5	0.0	0.9	2.2	4.2	0.49	48.0	26.1
Sudan	1968-1972	9.5	7.4	10.3	0.0	2.1	0.0	0.5	0.00	16.0	11.5
	1988-1992	17.1	12.9	17.2	0.0	2.3	0.0	0.6	0.00	27.0	17.9
Pakistan	1968-1972	11.0	11.2	12.2	7.8	0.6	0.3	1.4	0.04	17.0	20.3
	1988-1992	21.4	39.6	14.7	14.5	0.9	0.3	2.9	0.31	132.0	34.0
FACTOR		0.1	0.1	0.7	1.0	1.0	0.8	0.5	0.7	0.01	1.0

Sources: Livestock numbers from FAO, 1993a; livestock factors from Jahnke, 1982 - except buffalo from Kosilla, 1988

Appendix Table B Feeds and pasture offtakes ('000 tonnes) for livestock in selected WANA countries in 1968-1972 and 1988-1992

Appendix Table B Feeds and pasture offtakes ('000 tonnes) for livestock in selected WANA countries in 1968-1972 and 1988-1992

Country	Year	Feed or pasture																	Total ^{b)}		
		Wheat straw + stubble	Local barley grain	Barley straw + stubble	Rice straw	Local maize grain	Maize crop residues	Sorghum + millet residues	Sugar cane residues	Sugar beet residues	Lentil straw	Faba bean residues	Cotton residues	Cotton seed	Vetch forage	Oil meals	Imported barley	Imported maize		Other	Pasture ^{a)}
Fast population growth: oil and remittance sensitive																					
Yemen	1968-1972	55.4	124.0	161.2	0.0	16.0	48.0	2780.0	0.4	0.0	0.0	0.0	39.2	13.0	0.0	0.0	0.0	0.0	8032.0	11.27	
	1988-1992	185.1	51.0	66.3	0.0	61.6	184.8	1965.6	0.1	0.0	0.0	0.0	42.0	14.0	0.0	5.4	0.0	45.5	0.0	8032.0	10.64
Afghanistan	1968-1972	2926.0	360.2	468.0	500.5	723.0	2169.0	112.0	5.0	6.0	0.0	0.0	70.8	141.6	0.0	12.4	0.0	0.0	15000.0	22.35	
	1988-1992	2269.0	209.8	273.0	424.1	420.4	1261.2	97.6	5.0	0.2	0.0	0.0	37.2	2.0	0.0	28.0	0.0	0.0	15000.0	20.03	
Syria	1968-1972	1270.0	469.2	610.0	2.9	9.6	28.8	96.0	0.0	21.0	72.6	9.8	398.6	234.0	47.0	34.2	29.4	0.0	0.0	1574.0	4.67
	1988-1992	2689.0	1192.0	1550.0	0.0	163.8	491.4	23.2	0.0	0.0	3.6	12.4	517.8	279.0	0.0	235.6	34.0	159.8	0.0	1574.0	8.80
Jordan	1968-1972	183.0	27.4	36.0	0.0	0.2	0.6	1.6	0.0	0.0	17.2	1.8	0.0	0.0	0.0	0.0	12.6	20.4	0.0	675.0	0.98
	1988-1992	93.0	42.6	55.0	0.0	4.2	12.6	3.2	0.0	0.0	3.6	0.0	0.0	0.0	0.0	65.8	250.0	257.2	0.0	675.0	1.46
Transitional population growth: oil and remittance sensitive																					
Egypt	1968-1972	1995.0	102.6	133.0	3326.7	2366.0	7098.0	3423.2	701.0	0.0	39.2	296.0	1386.8	844.0	1.0	259.4	0.0	66.6	7100.0	360.0	28.66
	1988-1992	5041.0	142.0	185.0	3987.1	4753.0	14259.0	2570.4	1117.0	77.0	12.8	425.8	838.4	521.0	0.0	687.4	3.4	1418.4	7100.0	360.0	42.98
Lebanon	1968-1972	59.8	7.8	10.1	0.0	1.6	4.8	3.2	0.0	13.0	1.8	0.8	0.0	30.0	3.9	21.0	57.8	85.4	462.5	5.0	0.74
	1988-1992	72.8	18.4	23.9	0.0	3.0	9.0	7.2	0.2	5.9	10.0	1.8	0.0	30.0	3.9	169.4	43.0	146.0	462.5	5.0	0.98
Morocco	1968-1972	2644.0	2450.2	3185.0	38.7	0.0	0.0	307.2	0.0	120.0	18.4	205.0	22.4	13.0	13.0	4.2	10.4	8.2	0.0	10450.0	19.48
	1988-1992	4696.0	2584.8	3360.0	22.6	0.0	0.0	80.0	102.0	293.0	35.2	160.0	23.6	19.0	0.0	27.0	180.0	185.2	0.0	10450.0	22.20
Tunisia	1968-1972	838.0	161.6	210.0	0.0	0.0	0.0	29.6	0.0	4.0	1.0	23.4	0.0	0.0	0.0	0.0	21.2	13.0	0.0	2182.0	3.48
	1988-1992	1334.0	406.2	528.0	0.0	0.0	0.0	12.0	0.0	26.0	1.2	30.2	0.6	0.0	0.0	132.4	146.6	253.0	0.0	2182.0	5.05
Turkey	1968-1972	14598.0	3689.0	4796.0	306.3	1041.0	3123.0	214.4	0.0	484.0	100.2	43.2	1196.0	689.0	195.0	71.2	0.0	3.2	0.0	4275.0	34.14
	1988-1992	25085.0	6800.0	8840.0	321.9	2060.0	6180.0	24.0	0.0	1316.0	729.2	73.2	1594.0	953.0	0.0	685.4	337.4	284.6	0.0	4275.0	57.93
Oil exporters with large populations																					
Algeria	1968-1972	1890.0	518.2	674.0	4.9	5.8	17.4	7.2	0.0	7.0	8.0	0.0	1.6	1.0	2.0	6.2	23.6	11.0	0.0	9326.0	12.50
	1988-1992	1550.0	1026.8	1335.0	2.1	2.0	6.0	1.6	0.0	0.0	1.0	0.0	0.0	0.0	0.0	417.0	343.0	1202.2	0.0	9326.0	15.21
Iran	1968-1972	5462.0	1059.0	1377.0	1378.0	32.0	96.0	52.0	59.0	355.0	34.2	0.0	526.8	269.0	1.0	87.8	43.0	56.8	0.0	22000.0	32.62
	1988-1992	10473.0	3318.0	4314.0	2628.6	114.8	344.4	55.2	148.0	433.0	71.8	0.0	404.8	230.0	0.0	430.8	245.0	883.6	0.0	22000.0	45.87
Iraq	1968-1972	1925.0	809.8	1053.0	371.0	9.8	29.4	38.4	7.0	6.0	5.8	18.2	44.0	27.0	1.0	9.6	50.4	0.0	0.0	3616.0	7.99
	1988-1992	1220.0	1024.0	1332.0	244.7	150.0	450.0	19.2	4.0	1.0	0.6	9.4	13.0	9.0	0.0	108.8	163.0	224.6	0.0	3616.0	8.58
Oil exporters with small populations																					
Libya	1968-1972	56.0	84.6	110.0	0.0	1.2	3.6	3.2	0.0	0.0	0.0	1.8	0.0	0.0	0.0	0.0	107.4	0.0	0.0	1330.0	1.70
	1988-1992	202.0	136.8	178.0	0.0	0.8	2.4	8.8	0.0	0.0	0.0	9.6	0.0	0.0	0.0	160.2	455.6	134.4	0.0	1330.0	2.62
Oman	1968-1972	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	25.0	575.8	0.61
	1988-1992	6.5	0.0	0.7	0.0	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.0	0.0	74.0	575.8	0.68
Saudi Arabia	1968-1972	121.0	11.8	15.0	2.9	3.2	9.6	1054.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.8	0.0	0.0	1700.0	2.94
	1988-1992	4685.0	358.2	466.0	0.0	3.2	9.6	711.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	263.6	4960.0	812.0	0.0	1700.0	14.07
South and East WANA																					
Ethiopia	1968-1972	839.0	727.2	945.0	0.0	893.8	2681.4	3805.6	109.0	0.0	46.6	303.0	38.0	25.0	0.0	0.0	1.2	2400.0	22450.0	35.24	
	1988-1992	1128.0	965.6	1255.0	0.0	1782.0	5346.0	4792.0	160.0	0.0	34.6	277.0	59.2	43.0	0.0	0.0	0.0	2400.0	22450.0	40.65	
Sudan	1968-1972	159.0	0.0	0.0	5.5	23.8	71.4	6906.4	86.0	0.0	0.0	19.2	654.6	402.0	0.0	26.4	0.0	0.0	0.0	52000.0	59.95
	1988-1992	627.0	0.0	0.0	1.3	42.8	128.4	13179.2	410.0	0.0	0.0	43.6	339.0	235.0	0.0	93.6	0.0	0.0	0.0	52000.0	66.87
Pakistan	1968-1972	8761.0	100.6	131.0	4377.1	684.4	2053.2	2203.0	2512.0	19.0	22.4	0.0	1810.0	1134.0	0.0	367.6	0.0	3.6	0.0	33000.0	56.05
	1988-1992	18631.0	129.6	169.0	6236.1	1210.0	3630.0	1671.2	3607.0	37.0	30.0	0.0	4974.0	3240.0	0.0	1302.8	0.0	16.0	0.0	33000.0	74.64
FACTOR ^{c)}		1.3	1.0	1.3	1.3	1.0	3.0	4.0	0.1	0.1	1.0	1.0	2.0								

Notes:

a) Pasture offtake is for single years, 1970 and 1990 and is estimated for Algeria at 300 kg/ha; Egypt, 90; Jordan, 79; Libya, 100; Iraq, 110; Morocco, 500; Saudi Arabia, 20; Sudan, 500; Syria, 200; and Tunisia, 600 (ACSAD, 1985); Pakistan, (660 Noor, 1987); Lebanon, 470 plus 450000 tonnes forest grazing (Slayman *et al*, 1986); Afghanistan, Ethiopia, Iran and Turkey assumed at 500; Yemen, 500 (Hassan *et al*, 1982); Oman, total estimate 218000 tonnes (Wardeh *et al*, 1982)

b) Million tonnes

c) Crop yield data from FAO, 1983a multiplied by these factors based on Kosilla, 1988 and Nordblom, 1988

Sources: FAO, 1993a except berseem in Egypt (Abu Akkada, 1984), Lebanon (Slayman, 1986), Oman (Wardeh *et al*, 1982) and Pakistan (Noor, 1987) and teff in Ethiopia (Kategile *et al*, 1981)

Constraints and opportunities for livestock development in mixed farming systems in tropical Latin America and the Caribbean¹

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Introduction

Mixed systems that include crops and livestock are widespread at all altitudes in Latin America and the Caribbean (LAC) on small and medium sized farms. On larger farms, as in the South American savannas, integration is becoming common despite traditional separation of crops and livestock (Vera *et al*, 1992). This paper examines opportunities for development of the animal component of mixed farming systems in the tropical countries of the region. The emphasis is on cattle because they are the most widely distributed species and they contribute nearly half the meat and almost all of the milk produced in the LAC countries.

The socio-economic background

Major social, economic and environmental changes took place in the region in the last 20 years. The period 1980-1990 was characterized by stagnation or a fall in GDP, hyperinflation, acute fiscal deficits and large foreign debts. Population growth was more than two per cent per year (Appendix Table A). The 75 per cent urbanization distinguishes LAC from tropical Africa and parts of Asia. Macroeconomic adjustments to reduce market distortions and public deficits have been harsh in the short term. They have included removal of subsidies and caused lower production of staple foods, widespread unemployment and reduced social services. Public spending on agricultural research and support has decreased. Poverty increased (CEPAL, 1990) and, in addition to widespread rural poverty a rising proportion of the poorest households now live in cities. Civil disturbance, organized violence and crime symbolize the period. Recent improvements in some countries have been offset by deterioration in others and international war returned to the region in 1995.

Milk and beef are traditionally important in the Latin American diet with high income elasticities of demand in all economic strata (Rubinstein and Nores, 1980). Overall average consumption of milk and meat per caput remained fairly static between 1976-1983 and 1984-1991 (Appendix Table A) but more countries recorded decreases than increases in both products,

especially in Central America and the Caribbean. The serious deterioration in diet quality of the poorest families, documented recently in Venezuela, is masked by the average figures and is likely to be widespread.

Trends in cattle production and land use

Total milk production has increased by about two per cent per year since 1976 but has generally failed to keep up with population growth (Appendix Table B). Individual countries vary but there has been little overall change in yield per cow in most areas of the region except in the Caribbean where considerable progress has been made in Cuba. Tropical LAC produced 88 per cent of its milk requirements during 1984-1991. A deficit of nine million tonnes is predicted for the year 2000 (Seré, 1990).

Beef production has increased more rapidly than milk, especially in Mexico (Appendix Table C). Most expansion elsewhere, however has been from increases in inventory as yields per head have remained fairly stable. The region has been a net exporter of beef over the last two decades but a shortfall of 356000 tonnes is predicted by 2000 (Seré, 1990).

The trends described for production and yields have been associated with changes in the pattern of land use and production systems. Several related tendencies can be identified. Intensive, specialized dairy systems on high value lands and based largely on concentrate feeds derived from imported grains have tended to disappear in favour of dual purpose systems. Movement of national herds towards less fertile lands, as documented for Brazil and Colombia (Seré, 1990), has also been noted elsewhere in Central and South America. Lower costs and higher profits from milk production have been associated with systems of medium, rather than high, intensity (Wilkins *et al*, 1979; Holmann *et al*, 1990; Madalena *et al*, 1990) and milking in beef herds is becoming more common in an effort to intensify production.

There has been no significant increase in the amount of land under annual or perennial crops in any major area of the region (CIAT, 1993). Latin America, at 7.3 million ha/year, had, however, the highest rate of deforestation in the world during the 1980s (Serrao, 1994). Much of this area ended up as pasture land either because of direct substitution or because the cropping systems that replaced the forests were unsustainable. The area under permanent pastures in 1990 was 10 per cent greater than in 1974-1981 (CIAT, 1993) but 50 per cent of pastures in tropical LAC are now considered to be in an advanced state of degradation (Serrao and Toledo, 1990).

Opportunities for development

Against this background major opportunities for progress can be identified.

Firstly, much can be done so that cattle fit better into cropping systems in order to help achieve sustainable production in the whole system. Application of current knowledge to the use by ruminants of the residues and byproducts of major crops, including sugar cane and cereals, has yet to be fully exploited in Latin America. The role of locally grown supplements, including legumes, in achieving this goal through strategic balancing of dietary nutrients has been well emphasized (Preston and Leng, 1987). There is also evidence from various ecosystems to show the beneficial effects of grasses and legumes introduced into mixed systems as pasture, forage or edible cover crops. Reduced erosion and improved fertility, structure, water retention and biological activity in the soil have been recorded, as have associated increases in subsequent crop yields and reductions in fertilizer requirements (Sánchez and Ara, 1991; CIAT, 1992; Vera *et al*, 1992; Mares, 1994). The economic potential of mixed systems in the savannas is already known (Vera *et al*, 1992), as is the increase in animal production to be obtained from suitably adapted grasses and legumes (Table 1) but the

effect these deep rooted species may have on soil carbon storage has been demonstrated only recently (Fisher *et al*, 1994). Thus, besides their potential for increasing crop and animal production, introduced pastures based on adapted species may prove a substantial buffer for carbon dioxide emissions. If this is so, the widely held negative view of the effect of tropical pastures on the global environment would require revision.

Table 1 Effect on animal production and soil carbon storage of adapted forages introduced into Colombian savannas

Item	Forage type		Difference (%)
	Native savanna	<i>Brachiaria</i> spp. + <i>Arachis pintoi</i>	
Animal production			
Stocking rate/ha	0.2	2.4	1100
Weight gain (kg/yr)			
per head	60	183	205
per hectare	12	440	3567
Carbon storage (t/ha)			
0-40 cm	122.7	159.3	30
41-80 cm	74.3	108.4	46
Total	197.0	267.7	36

Sources: Paladines and Leal, 1979; Fisher *et al*, 1994; Lascano, 1994

Secondly, tropical pastures are important in the recuperation of lands that have been degraded by mismanagement. The introduction of cattle because soil is too depleted to continue to produce crops is widespread, as is the case on small and medium holdings in Costa Rica (Thrupp, 1980). Increases in cattle production of 200-400 per cent have resulted from grass and grass-legume mixtures introduced in degraded rainforest pastures where properly adapted and adequately managed germplasm has been used (CIAT, 1992). Pioneer crops can help defray the costs and varieties suitable for infertile, acid soils have reached economically attractive levels of yield in the savannas and humid tropics (CIAT, 1992; Vera *et al*, 1992). Regional experience suggests that pastures in the humid tropics have a high potential for sustainable use (Sanchez and Ara, 1991). It has been estimated that the degraded pastures left by deforestation in the Amazon basin can be brought into sustainable use and meet the region's requirements for meat and milk until at least 2000 by using currently available technology (Serrao, 1994).

Thirdly, there is undoubtedly much room for better animal performance in the systems that seem likely to prove sustainable. One example is the magnitude of differences between neighbouring farms that have dual purpose cattle and cereal cropping enterprises (Table 2). Variations of 28-123 per cent in major production traits were associated with forage quality and quantity, levels of legume or multi-nutrient block supplementation, water availability, daily walking distance, preventive medicine and cattle genotype. A second example shows how the correct genotype depends on system intensity and can be of major economic significance (Table 3). Mismatches are still common, especially in milked herds where high grade and pure European cattle are often over-represented. Evidence from Venezuela indicates that about 150 per cent more milk and beef could be produced from the existing national herd if technologies for the efficient use of local resources were applied on an integrated basis (Plasse, 1992). This work, based on experiments validated over many years on commercial farms, is likely to be widely applicable elsewhere in lowland tropical LAC.

Table 2 Differences in performance between neighbouring farms using a cattle-cereal

production system in Venezuela

Trait	Least squares adjusted mean ^{a)}		Difference (%)
	Min	Max	
Lactation yield (kg)	556	1080	94
Days open	114	189	66
Mortality, 0-4 mo (%)	5.2	11.6	123
Calf weight, 4 mo	61	78	28

Note:

^{a)} 6 farms, 152-627 observations/farm

Table 3 Relative economic merit of cattle breed groups in tropical South American production systems

System/country	System intensity	Relative profit (100 = most profitable group in each case)				Source
		Local/zebu type	European crossbred			
			Low	Medium	High/pure	
Cereal-grazing						
Venezuela ^{a)}	Low	100	-	97	87	Vaccaro <i>et al</i> , 1994
Grazing						
Bolivia	Low	100	-	-	-300	Wilkins <i>et al</i> , 1979
Venezuela ^{a)}	Medium	-	-	100	45	Holmann <i>et al</i> , 1990
Brazil	Medium	-	50	100	58	Madalena <i>et al</i> , 1990
Brazil	High	-	35	100	90	Madalena <i>et al</i> , 1990
Venezuela	High	90	-	100	94	Vaccaro <i>et al</i> , 1994

Note:

^{a)} Data relate to relative gross income

Constraints to livestock development

The conceptual framework

There are strong arguments in support of the view that the main constraint in tropical LAC is conceptual rather than technical.

Animal, crop and environmental sciences are usually separated in teaching, research and development planning in LAC. The social sciences often have little more than a token role in these activities.

Animal production and veterinary medicine are also frequently separated and are indeed still notorious for their rivalry. Most LAC countries now have ministries dealing with environmental issues but these are almost always disconnected from agriculture and forestry. These

separations are exacerbated by the traditional organization of research institutions along disciplinary lines, by universities and their curricula, and by the highly theoretical content of university course work.

Animal scientists, now increasingly from cities, are frequently ignorant of practical problems and unaware of the broader production systems context, sustainability issues and current social concerns. One study of tropical forages and grassland in LAC concluded that the knowledge of the last 12-15 years, together with emerging social concerns, had yet to be adequately incorporated into university teaching (Nores and Vera, 1993) and that the most frequently used textbooks were published before 1980. A survey of 33 universities in 13 countries showed that only 57 per cent of professors did research and that this occupied less than 40 per cent of their time. Low budgets allow little opportunity for on-farm research and isolate universities further from reality. Teaching, understandably, is biased towards the well documented intensive models of temperate countries. In the past even prestigious public agricultural research institutions gave low priority to further training unless this was externally funded and, with notable exceptions, has changed little or for the worse (Ardila *et al*, 1982).

It is not surprising, therefore, that much of the research done by national institutions in tropical LAC appears to be divorced from urgent problems. Two case studies illustrate this point. In the first a sample of papers published in 1973-1984 shows that the proportion relating to dual purpose compared with specialized dairy cattle is almost the reverse of their numerical importance (Table 4). This is in contradiction to the evidence (Table 3) that European type dairy cows may have very little place in sustainable tropical production systems. Judging by disciplinary distribution the apparent neglect of research in such critical fields as systems, management, economics and forages is very instructive.

Table 4 Frequency of research papers on cattle in dual purpose (75-per cent of milked cow population) and specialized dairy systems (25 per cent of milked cow population) compared to their relative importance in tropical LAC^{a)}

Item	Percentage of papers on	
	Dual purpose systems	Specialized dairying
All research papers (n = 202) ^{b)}	14	73
Discipline		
Genetics (68)	19	1
Reproduction (54)	44	56
Nutrition (53)	11	89
Health (8)	63	37
Forages (7)	0	100
Management (5)	40	60
Economics (4)	75	25
Systems (3)	66	34

Notes:

^{a)} Seré and Rivas, 1987

^{b)} Papers in major LAC journals 1973-1984, adapted from Vaccaro, 1986

The second case relates to publications on forage and grasslands abstracted from a data base serving the needs of tropical LAC scientists. Only 22 per cent of publications were related to problem solving research and only seven per cent had any explicit socio-economic

perspective (Nores and Vera, 1993). The conclusion from this and other sources is that the profession seemed to be "talking to itself". The situation is now somewhat better but these examples represent sadly wasted opportunities and depict a legacy of slow and difficult change.

Radical modernization of basic research and training concepts in animal science is required to ensure that advantage is taken of the abundant opportunities and to ensure that the frontier of knowledge is carried forward fast enough to meet future needs. Livestock scientists must become properly conscious of the role of the animal as a component of sustainable systems rather than as an end in itself. Emphasis on high yields per animal will then give place to one on the long- term social benefits of the system as a whole. A powerful aid to achieving this change is provided by on-farm teaching and research. Cooperative models in which institutions, including universities, and farmers participate in carrying out a mutually agreed research agenda have been successful in the region. Farmers have proved willing to provide financial support even in such disciplines as animal breeding where results take a long time to emerge. Such models obviate the risk of irrelevance and ease the task of the extension services.

Information exchange is another critical ingredient of research and training. Reputable animal science journals are very scarce in Latin America and many scientists and most university students have difficulty reading anything except Spanish and Portuguese. They are concurrently confronted with a daunting volume, not all of which is useful, of literature. An urgent case can be made for an information system which filters that which is relevant to animal science in sustainable tropical production systems and shares translated texts among continents.

Policy

Inappropriate policies are a direct consequence of the conceptual framework just described. They are perhaps the most serious constraint to progress in the livestock sector. The effects range from lost opportunities in promoting development to active damage to the economy and the environment. The most notorious examples include the complex issue of deforestation and cattle ranching in the Amazon basin (Mares, 1994) and the subsidized import of European cattle (Jarvis, 1990), whose consistently poor performance (Table 3) was already predictable.

Policies related to the livestock sector are generally short term because of political instability and too fragmented to be effective. Issues such as land tenure, rural security markets and prices, credit, input and product quality control - which are all crucial in LAC - are often neglected. It is common to find government technical services in one area (e.g. reproduction and genetics) incompatible with another (e.g. feed resources) and with the main production systems. These problems of incoherence and instability must obviously be corrected.

The greatest need is for policies which are holistic and not simply centred on livestock. The next, and vital, dimension is that they should be designed to make rational and sustainable use of resources and to balance the needs of all sectors of the community. They will thus promote the long term productivity of overall production systems by optimizing the use of the animals within them. In addition to political will this is a complex area in need of new expertise and urgent research. If development policies are set in this way the technical aspects related to the livestock component will fall more clearly into place.

Technical aspects

Available technology can substantially increase livestock production but growing needs demand advances that must come from research. This section tries to predict agendas in different areas while recognizing that progress depends on advances in each being integrated

as a coherent whole.

Systems

Research on livestock production systems has at least a 20-year history in the region (Ruiz, 1989). It was criticized initially for being too concerned with methodology and diagnostic work. Revitalized, it now has a crucial role in understanding the dynamics of holistically defined systems especially if adequate attention is to be paid to current social, economic and environmental concerns. There is a shortage of qualified personnel and local training centres but successful advances will have major consequences for priority setting in all other research domains.

Feed resources

Poor nutrition is widely recognized as a major constraint to animals kept on a basic diet of tropical grazing and crop residues and by-products in LAC. Vigorous research is being pursued in this domain with particular attention to local resources to complement the nutrient content of the basic diet (Combellas and Mata, 1992; Pezo *et al.*, 1992). There are still major gaps in the knowledge of the reproduction, agronomy and utilization of many promising plant species, especially legumes, which may be able to fulfil this role. Variation in the ability to contribute to environmental conservation will also receive more attention. Better integration of crop-livestock systems should encourage plant breeders to monitor the value to livestock of residues and by-products in their selection programmes.

Genetics

LAC has generated one of the major bodies of information on the genetics of tropical beef cattle but is less advanced in dual purpose animals. Work is needed to achieve a better understanding of the very important genotype: environment interactions, to validate the results of mating systems in crossbred populations and to determine the genetic parameters of economically useful traits. Tropical LAC is the home of various endangered "native" (Criollo) breeds but blanket recommendations for conservation are not credible, especially where resources are scarce. Research should be directed to methods of differentiating genotypes which justify conservation from those which may not, this also being an issue of concern in other developing regions.

Health

The impact of disease on cattle production in LAC is extremely heavy and in cases such as foot and mouth disease is a factor limiting export development. A major part of the health problem in the region is, however, confounded with inappropriate production and management systems, malnutrition and the use of unsuitable genotypes. It should thus be considerably reduced as improvements in these aspects become more widespread. Control methods for the major infectious and contagious diseases are well known but the future depends mainly on resources and political decisions. Reproductive disfunction and parasitic disease are, however, areas of immense economic importance in the region and pose particular problems through their interactions with genetics and nutrition. They would therefore seem to be areas where research is particularly justified.

Conclusions

Despite a privileged place compared to other parts of the tropical world LAC suffers major problems of poverty and violence, declining standards of living for large sectors of society and environmental degradation. Cattle have a demonstrably important role in improving this situation and much current technology can do this. Yet progress has been slow and

opportunities lost. A holistic, integrated concept of production is the most important single factor for harnessing resources and catalysing change. Once this is in place, policies conducive to the sustainable development of systems including livestock will be set more widely and appropriate research and training to serve future needs can be undertaken.

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Appendixes

Appendix Table A Trends in population growth and consumption of and beef in tropical LAC from 1976-1983 to 1984-1991

Area	Population growth (%/year)		Consumption (kg/caput/year)			
			Milk		Beef	
	1976-1983	1984-1991	1976-1983	1984-1991	1976-1983	1984-1991
Mexico	2.5	2.2	111	98	11	18
Central America	2.7	2.7	90	74	12	10
Caribbean	1.4	1.5	90	86	14	13
Tropical South America	2.6	2.5	91	91	17	16
Brazil	2.3	2.1	94	100	17	15
Tropical LAC	2.4	2.2	96	95	15	16

Source: CIAT, 1993 from FAO data

Appendix Table B Changes in milk production in tropical LAC from 1976-1983 to 1974-1991

Area	Production growth (%/year)				Yield (kg/cow)	
	Total		Per caput			
	1976-1983	1984-1991	1976-1983	1984-1991	1976-1983	1984-1991
Mexico	2.0	-1.4	-0.5	-3.6	1245	1205
Central America	-3.9	0.3	-6.6	-2.5	891	965
Caribbean	4.7	0.3	3.3	-1.2	1377	1585
Tropical South America	2.5	2.8	-0.2	0.3	1113	1167
Brazil	2.6	3.4	0.3	1.3	739	750
Tropical LAC	2.4	1.9	-0.2	-0.3	935	946

Source: CIAT, 1993 from FAO data

Appendix Table C Changes in beef production in tropical LAC from 1976-1983 to 1974-1991

Area	Production growth (%/year)				Yield (kg/cow)	
	Total		Per caput			
	1976-1983	1984-1991	1976-1983	1984-1991	1976-1983	1984-1991
Mexico	4.2	10.8	1.8	8.6	27	43
Central America	-3.9	1.7	-6.5	-1.0	30	27
Caribbean	0.4	0.4	-1.0	-1.1	27	28
Tropical South America	2.0	4.4	-0.6	2.0	24	25
Brazil	0.2	5.1	-2.1	3.0	20	18
Tropical LAC	1.1	5.8	-1.3	3.6	23	23

Source: CIAT, 1993 from FAO data

Mixed farming and intensification of animal production systems in Asia

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Introduction

Mixed farming systems are the backbone of Asian agriculture (Devendra, 1983). These systems have many distinctive features including:

- diversification in the use of production resources:
- reduction in, and spread of, risk;
- small size of most farms;
- large populations of ruminants (buffalo, cattle, goats and sheep) and non-ruminants (chicken ducks and pigs);
- integration of crops and animals:
- multipurpose roles of crops and animals;
- low use of inputs and traditional systems;
- location in the three main agroecosystems (highlands, semiarid and arid tropics, and subhumid/humid tropics).

These integrated farming systems involve several subsystems including crops, animals and fish. Synergistic interactions have a greater total effect than the sum of the individual effects (Edwards *et al*, 1988). Ecological and economic sustainability is achieved when the natural resources of land, crops, animals and water are used to reinforce each other.

Mixed farming systems in the Asian region are varied. Farming practices have developed as a response to environmental dictates, especially temperature, rainfall, altitude, type and intensity of animal production and human intervention. Diversification of resource use spreads risk and provides stability. Farmers consciously diversify the use of the resources to produce a mix of activities that are economically rewarding. Within this broad variety of agricultural activities, opportunities are

created that enable switching of practices within and between crops and animals. Diversification rather than specialization is the primary consideration.

The inclusion of animals is based on the consideration that they provide power, food, a supplementary income, insurance and a safe investment. Seldom are more than two species of ruminants reared together. Among the agroecosystems feed supplies are most abundant in the humid areas and here ruminants are valuable in converting feed to animal products that include meat, milk, fibre and power.

This paper describes the genesis of mixed crop-animal systems and their characteristics, the various types of mixed farming systems, major constraints to production in specific agroecosystems and the opportunities for research and development to increase productivity. It further discusses intensification of animal production systems and the role of ruminants and non-ruminants.

Economic importance of animals

The economic importance of animals in Asian mixed farming systems is considerable but is often underestimated. Their value increases with a shift from subsistence agriculture to market oriented economics and intensification of production. Within mixed systems the economic contribution of animals becomes ever more significant when these types of changes, including increased sustainability, occur.

The annual value of crop, livestock and forestry output in developing countries has been estimated at US \$ 605 billion, to which livestock contribute 19 per cent (TAC/CGIAR, 1992). Asia accounts for 59 per cent of the total value (Table 1). The priority ecoregions of the semiarid tropics and subtropics with summer rainfall and the warm humid and sub humid tropics and subtropics contribute 43.4 per cent of total value (Table 2). In these regions about 22.5 per cent is from the warm humid and subhumid tropics and subtropics where traditional mixed farming systems predominate. These figures are certainly underestimated as they do not include the major contributions of draught power and manure.

The concentration of domestic animals varies across agroecological zones (Table 3). Small ruminants are found mainly in the rainfed lowlands and the upland areas and are especially valuable for fibre and meat, and also for transport, in the Hindu Kush and Himalayan highlands. Large ruminants are more heavily concentrated in the irrigated lowlands where their value is mainly for draught and haulage.

Table 1 Shares of crops, livestock and trees in total agricultural output (US \$ billion/year) in developing regions, 1987-1989

Commodity group	Region				Total	Per cent share
	Asia	SSA	LAC	WANA		
Crops	222	35	74	33	364	57
Livestock	64	10	36	12	122	19
Trees	73	19	25	2	119	19
Total	20	2	10	1	33	5
Per cent share	59	10	23	8		

Source: TAC/CGIAR, 1992

Table 2 Contribution (per cent) to total value of livestock output by developing regions and agroecological zones, 1988-1989

Agroecological zone	Developing region				Total for zone
	Asia	SSA	WANA	LAC	
Warm arid and semiarid tropics	7.8	4.2	-	2.3	14.2
Warm subhumid tropics	3.4	1.2	-	4.5	9.2

Warm humid tropics	4.7	1.0	-	4.6	10.3
Cool tropics	-	1.6	-	5.2	6.8
Warm arid and semiarid tropics (summer rain)	12.0	-	-	1.8	13.8
Warm subhumid tropics (summer rain)	4.6	-	-	0.8	5.5
Warm/cool humid subtropics (summer rain)	10.9	-	-	4.6	15.5
Cool subtropics (summer rainfall)	9.2	-	-	4.6	13.8
Cool subtropics (winter rainfall)	-	-	10.0	0.9	10.9
Total for region	52.6	8.0	10.0	29.3	100.0
Total value (US \$ billion)	63398	9718	12175	35593	121424

Source: TAC/CGIAR, 1992

Table 3 Distribution of domestic livestock by ecosystem and subregion in Asia

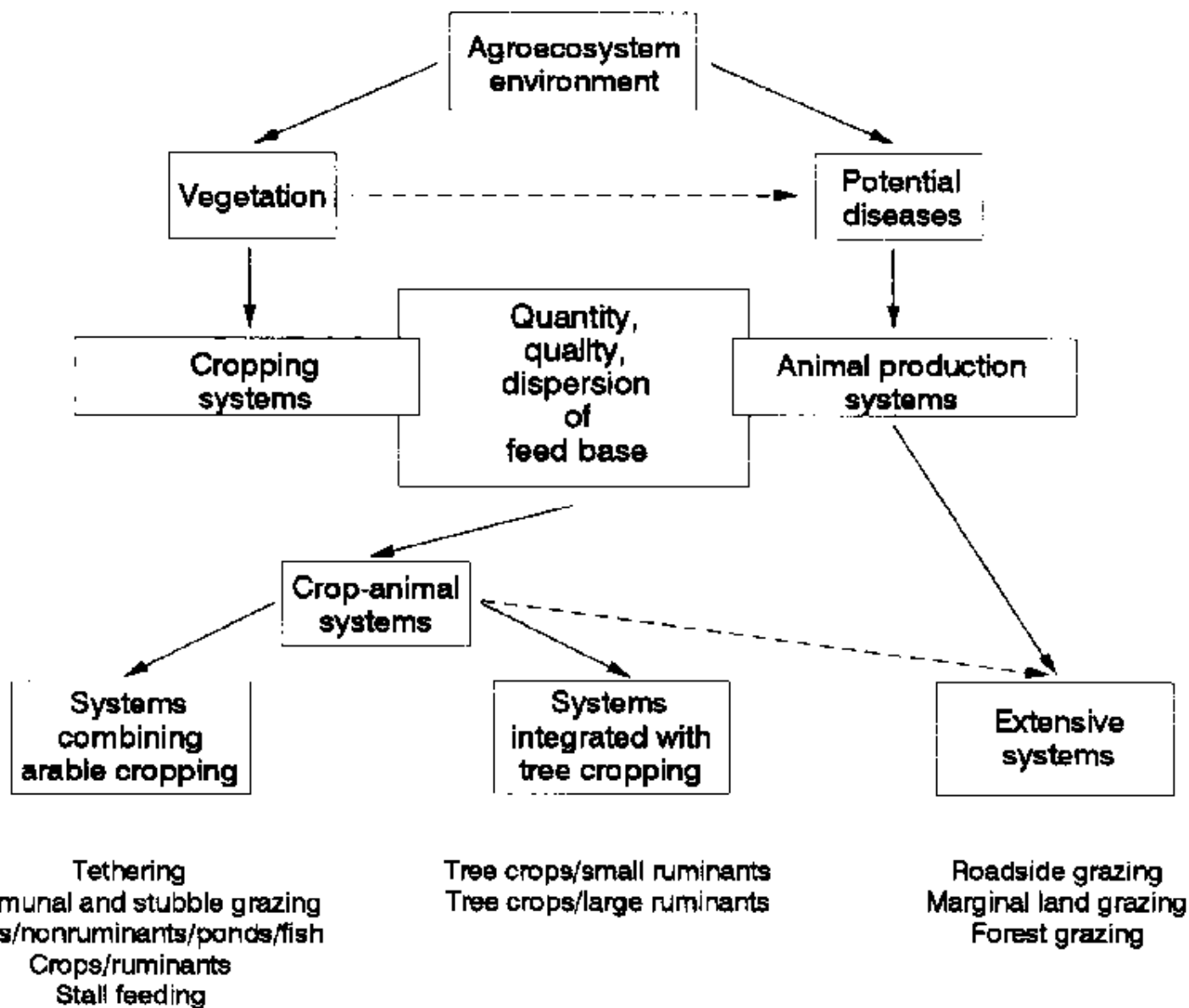
Subregion	Agroecosystem and livestock species											
	Lowland irrigated			Lowland/upland rainfed			Semiarid and arid			Highlands		
	Buffalo/ cattle	Goat/ sheep	Non- ruminant	Buffalo/ cattle	Goat/ sheep	Non- ruminant	Buffalo/ cattle	Goat/ sheep	Non- ruminant	Buffalo/ cattle	Goat/ sheep	Non- ruminant
China	***	*	***	**	***	***	*	***	*	**	***	*
Hindu Kush	***	*	**	**	***	*	*	-	-	*	***	*
South Asia	***	*	**	**	***	**	*	***	-	*	*	*
Indochina	***	*	***	**	**	***	**	*	-	*	*	*
Southeast Asia	***	*	***	**	**	***	*	**	*	*	*	*

Source: Devendra, 1994

Genesis of crop-animal systems

Crop-animal systems have evolved and developed over many centuries. The principal determinants of the type of crop and animal systems in a particular location are the agroecological conditions (Duckham and Masefield, 1970; Spedding, 1975; Ruthenberg, 1980; Sere and Steinfeld, 1994). Climate and, to a lesser extent, soil affect natural vegetation and determine what crops can be grown. These in turn determine the feed base and its quantity, quality and distribution. The feed base, together with the disease challenge, governs the development of potential animal production systems. Feed resources provide a direct link between crops and animals and the interaction of the two largely dictates the development of such systems (Figure 1).

Figure 1 Genesis and types of animal production systems in Asia



Animal production systems

Animal production involves both non-ruminants and ruminants and a variety of systems integrated with crops. Systems vary as a function of agroecological zone and intensity of farming operations. Development of these systems has considerable potential, the benefits being associated with the complementary interactions of the subsystems, the products being additive. Two examples of such integrated systems, their economic benefits and their contribution to sustainability are: pig-duck-fish-vegetable systems in Indochina, Indonesia and the Philippines; and small ruminant-tree cropping systems throughout Southeast Asia and the Pacific (Devendra, 1993).

Ruminant production systems are of three main types: extensive systems; systems combining arable cropping including roadside, communal and arable grazing systems, tethering or cut and carry feeding; and systems integrated with tree cropping

These systems are unlikely to change in the for-seeable future. New systems and the returns from them would have to be demonstrably superior to present ones and supported by massive capital and other resources (Mahadevan and Devendra, 1986; Devendra, 1989). It can be predicted, however, that there will be increasing intensification and a shift from extensive systems to ones including arable cropping. These changes will be induced by population growth and because population density and land use intensity are positively correlated (Boserup, 1981). This situation is

increasingly likely with the decreasing availability of arable land that will occur in many parts of Southeast Asia. The principal aim should therefore be improved feeding and nutrition to maximize the use of available feed resources, especially crop residues, low quality roughages and leguminous forages.

Types of mixed farming systems

Two broad categories of mixed farming systems can be identified:

- systems combining animals and annual cropping in which there are two further subtypes
 - systems involving non-ruminants, ponds and fish
 - systems involving ruminants; and
- systems combining animals and perennial cropping in which there are again two subtypes
 - systems involving ruminants
 - systems involving non-ruminants.

Five distinct types of mixed farming systems are found in Asia in the various agroecological zones (Table 4). The length of the growing period is indicative of the combined effects of rainfed soil moisture and temperature and is defined as the period in days during the year when rainfed available soil moisture supply is greater than half the potential evapotranspiration.

An important element of mixed farming systems, and especially the contribution of animals to viability and stability, is the use of draught in the Philippines and Thailand. Of particular significance is the fact that for farm sizes of up to 2 ha both manure and animal power were important, but the role of the latter was more significant than the former. Only 2.3 per cent of farms use mechanical power (Table 5).

Development in the past has tended to focus on lowland irrigated systems which are now overcultivated. As increased productivity is the main objective, research and development efforts in the future must shift to the lowland rainfed areas which have large numbers of animals. These areas are generally more fragile and complex so research will be more challenging and become increasingly multidisciplinary and holistic.

Rainfed temperate and tropical highlands (MRT)

The Hindu Kush-Himalayan region is an excellent example of mixed farming involving both animals and subsistence crops. Yaks are multipurpose animals for tillage, transport, milk, meat and hair. Sheep and goats provide meat, milk and fibre and some pack services. The main crops are potatoes, barley, wheat, millet and fruits. Feed conservation is essential because of the short growing period.

Table 4 Agroecological zones and mixed farming systems in Asia

Agroecological zone	Growing period (days)	Crops	Animal	Mixed farming benefits
Rainfed temperate and tropical highlands	< 110	Barley, millet, potatoes, fruits	Yak, cattle, sheep	Traction, transport, manure, reduced risk, survival
Rainfed humid and subhumid tropics (MRH)	180-365	Maize, rice, wheat, sugar cane, plantation crops	Buffalo, cattle, pigs, chickens, ducks	Traction, transport, income, manure, crop residues
Rainfed arid and semiarid tropics	75-180	Sorghum, rice, millet, groundnuts soya beans,	Camels, donkeys, cattle goats, sheep,	Traction, transport, income, manure, reduced

(MRA)		pigeon, pea, cotton	chickens	risk, survival
Irrigated humid/subhumid tropics (MIH)	180-365	As MRH	As MRH	As MRH
Irrigated arid/semiarid tropics (MIA)	75-180	As MRA	As MRA	As MRA

Source: Devendra, 1984

Table 5 Sources of farm power (per cent) on various sized farms in the Philippines and Thailand

Farm size (ha)	Total farms	Source of power			
		Hand	Animal draught	Mechanical	Mechanical + animal draught
< 1	896	40	55	2	3
1-2	1374	19	75	2	4
2-5	1957	14	76	2	8
> 5	1149	7	74	3	16
Total	5376	18	72	2	8

Source: adapted from FAO, 1993a

Rainfed humid/subhumid tropics (MRH)

The system includes mainly annual cereals, soya beans and vegetables, ruminants and non-ruminants. Cattle and buffalo are the most common ruminants. There are fewer sheep and goats due to higher rainfall and humidity. Pigs and chickens are common and thrive on crop by-products. In upland areas tree crops such as coconuts, oil palm and rubber are becoming common. In much of Southeast Asia the native herbage under trees enables integration of livestock, especially small ruminants, and the development of a sustainable animal production system (Devendra, 1991; 1993). Many types of small farm systems are found here and operate at variable levels of intensity.

Rainfed arid/semiarid and subtropics (MRA)

Rainfall is much lower in this zone, this being a major constraint to crop growth. The main crops are millets, sorghum and date palm. This is the natural home of small ruminants and camels which provide security and survival for very poor farmers and landless peasants. Limited crop growth is associated with reduced feed availability. In South Asia, northeast Thailand and eastern Indonesia, where this ecosystem is common, increasing human and animal population pressures have resulted in severe resource degradation. Animal production is usually more extensive than in the previous agroecological zone.

Irrigated humid/subhumid tropics (MIH)

This high rainfall area is the heartland of intensive cropping. Most swamp buffalo and, to a lesser extent, cattle are found here and are closely associated with draught and transport operations. Buffalo are worked on about 110 days per year in these areas (Chantalakhana and Banyawechewin, 1994). Farmers are generally wealthier than in other agroecosystems. Increasing labour productivity and affluence are reflected in more use of tractors for cultivation. Ducks do well in this environment and pigs and poultry thrive on the abundant crop residues. Animals and intensive crop production in this ecozone are an illustration of a successful integrated and sustainable agricultural system.

Irrigated arid/semiarid tropics and subtropics (MIA)

These areas are mainly in South Asia and animals are of secondary importance. Large and small ruminants subsist on crop residues and limited grazing. Irrigation allows increased fodder production which reduces the feed deficit and promotes dairy development especially in periurban areas.

Relevance of integrated systems

The relevance and potential importance of integrated systems is associated with the complementarity of the crop and animal subsystems resulting in increased total productivity. In this context there are eight major advantages of integrated systems:

- diverse and efficient resource use;
- reduced risk;
- better use of farm labour for higher productivity and increased income;
- improved use of space:
- efficient use of biological and chemical energy in the system and less dependence on external inputs;
- development of sustainable systems that use recycling, involve no pollution and are consistent with environmental protection;
- increased economic output; and
- development of stable farm households.

Systems combining animals and annual cropping

Three-strata forage system (Indonesia)

The three-strata forage systems (TSFS) is a way of producing and conserving the feed requirements of cattle and goats without degradation of the environment. In dryland farming areas such as eastern Indonesia and South Asia the system combines production of food crops, including maize, groundnuts, cassava and pigeon pea, with shrubs and trees to supply year round feed for stock (Nitis *et al*, 1990). Highlights of the system, whose concept and technology are now becoming institutionalized, are:

- increased forage production allows higher stocking rates and live weight gains (3.2 animal units equivalent to 375 kg/ha/yr in the TSFS compared to 2.1 units or 122 kg/ha/yr in the non-TSFS);
- 19 per cent more live weight gain by cattle to reach market weight 13 per cent earlier;
- farm income raised by 31 per cent (addition of goats to the system raises income further);
- soil erosion reduced by 57 per cent by introduction of forage legumes and increased soil fertility; and
- production of 1.5 m.t. of fuel wood, meeting 64 per cent of annual needs, from 2000 shrubs and 112 trees logged twice a year.

Rice-fish-duck system (Indonesia)

The success and rapid expansion of the rice-fish system in particular (and the inclusion of ducks in Indonesia) is an example of the efficiency of integrated natural resource use and its economic benefits.

Net returns from a rice-fish-duck system (Table 6) were more than double than from rice alone. Fish production, at 185 kg/ha, was also much higher than the yield from traditional systems. The ratio of the net returns on inputs per year in the rice-rice-fallow and rice-rice-fish were 115-125 per cent

whereas in the (rice + fish) - (rice + fish) - fish they were 173 per cent (Yunus *et al*, 1992). Income from fish was able to meet 20-59 per cent of the total cost of rice production in the rice-rice-fish and (rice + fish)- fish systems.

Table 6 Returns over one year to a rice-fish-duck system and rice monoculture at Sukhamandi Experiment Station, Indonesia

System	Physical performance			Financial performance (US \$)		
	Rice (kg)	Eggs (N °)	Fish (kg)	Costs	Output	Net returns
(Rice + fish + ducks)-(Rice + ducks + fish)-Ducks	11708	17031	185	1632.6	3692.3	2059.7
Rice-rice-fallow	11268	-	-	812.5	1762.3	949.8

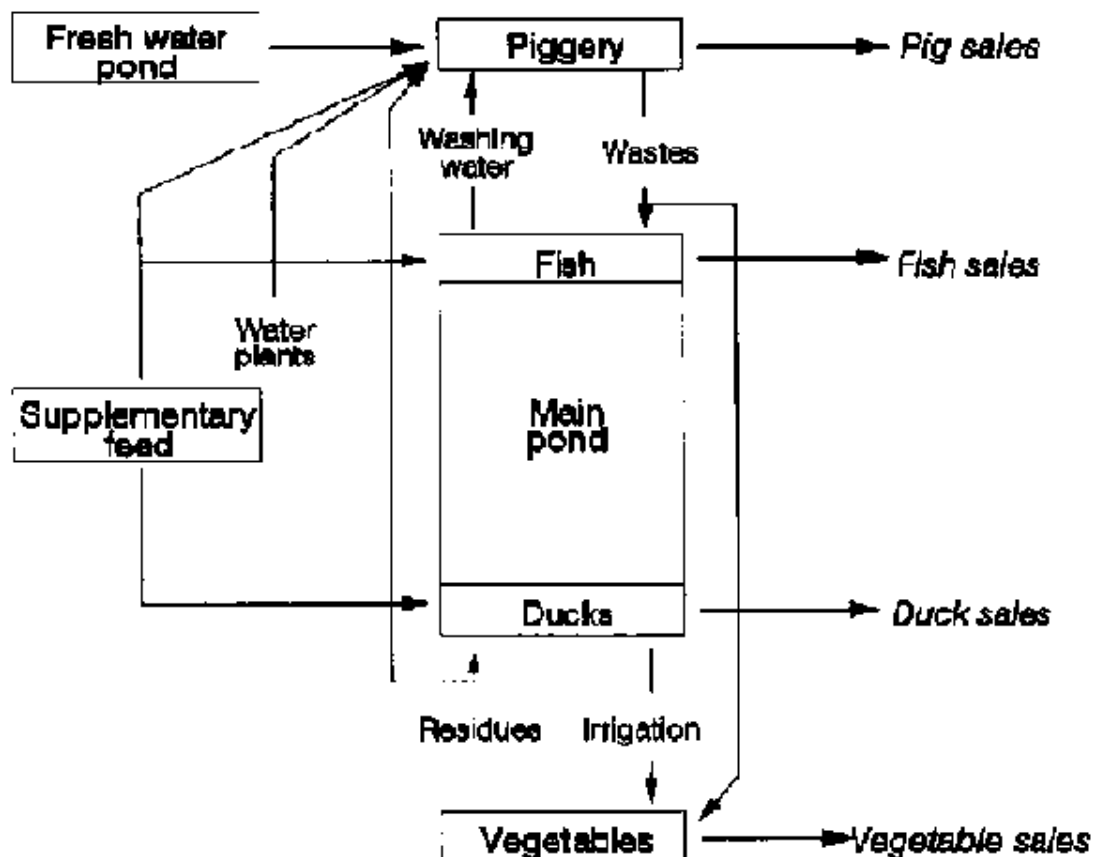
Source: Suriapermana *et al*, 1988

Similar economic benefits in integrated fish-duck-goat systems are reported from the Philippines (Cruz and Shehadeh, 1990), Malaysia (Mukherjee *et al*, 1992), China (Chen, 1992), Vietnam (Le Hong Man, 1992), Thailand (Little *et al*, 1992) and Bangladesh (Huque, 1992).

Pig-fish integration (China)

Two types of approach have been used to develop integrated pig and fish systems. One is the use of ponds in which several species (polyculture) of fish fingerlings are raised with pigs. The other is the use of water reservoirs for pig-fish systems. In both systems the integration of pigs, fish and ducks, and even vegetables, is a very efficient and intensive system of using natural resources (Figure 2).

Figure 2 Flows through an integrated pig-fish-duck-vegetable system



An example of the first system concerns polyculture of fish stocked at 10000-20000 fingerlings/ha

combined with 40-60 pigs with an average initial weight of 20 kg per hectare. Best results were obtained with 60 pigs and 20000 fish/ha to produce 1.9 m.t. fish/ha/90 days and 60 pigs with a total live weight gain of 2.2 m.t./90 days. Three cycles of 90 days produce 3.9 m.t. of fish and 6.7 m.t live weight gain of pig (Cruz and Shehadeh, 1990).

In the reservoir system several species of fish were raised with pigs and pearl grass at a number of locations in Zeijiang province. Pig manure was fermented before use or put into biogas digesters to eradicate pathogenic bacteria and parasites to prevent fish diseases (Lee and Zhen, 1990). Fish yields of 6.5-14.5 m.t./ha/yr were recorded.

Crop-animal system (Philippines)

In the rainfed lowland areas of Pangasinan in the Philippines, rice-mung bean has replaced rice-fallow. Intercropping with siratro and incorporation of the herbage as green manure from the last cutting two weeks before replanting into the soil resulted in higher yields of the succeeding crop (Table 7).

Table 7 Yields of rice and intercrops in Pangasinan, Philippines

Cropping system	Yield (m.t./ha)	
	Rice	Mung bean
Rice-fallow-rice	3.0	-
Rice-mung bean-rice	3.7	1.0-1.5
Rice -(mung bean + siratro)- rice	4.5	1.0-1.5

Cattle fed rice straw as the basal feed supplemented with siratro and mung beans, rice bran and urea generally had better weight gains and lowered weight loss. The technology has now been widely adopted. The benefits of this system are:

- increased yield of rice and farm income;
- 50-70 per cent reduction in dependence on and cost of organic fertilisers;
- increased forage biomass;
- increased cattle carrying capacity;
- availability of feed for cattle calving at the end of the wet season and the start of the dry season when feed deficits are a major constraint to production;
- development of all year round feeding systems; and
- increased output from animals.

Combined animal and perennial crop systems

Integrated oil palm-ruminants system (Malaysia)

The integrated tree cropping-ruminant system has not been adequately exploited in view of its considerable benefits. The potential for this system derives from an estimated area of 535 million ha (FAO, 1993b) under forests and woodland of which a high proportion is coconuts, oil palm and rubber. A study of the effects of grazing with cattle and goats compared to no grazing in young and mature oil palms showed that grazing resulted in increased yields of 2.2-5.2 m.t./ha/yr of fresh fruit bunches (Table 8). In view of the total area under oil palm and the value of fresh fruit bunches per tonne the economic advantage is substantial. Similar results are reported for integration of small ruminants with rubber or coconuts in Malaysia and the Philippines.

Table 8 Effects of mixed cattle and goat grazing on fresh fruit bunch yields (m.t./ha/yr) of oil palm in Malaysia

Year	System		Difference
	Grazed ^{a)}	Ungrazed	
1980	30.55	25.61	4.94
1981	17.69	15.87	1.82
1982	25.12	22.97	2.15
1983	23.45	18.29	5.16
Mean	24.20	20.29	3.51

Note:

a) Cattle only in 1980 and 1981, cattle and goats in 1982 and 1983

Source: Devendra, 1991

Crop-animal systems (Sri Lanka)

In the upland areas in central Sri Lanka crop production involves trees (coconuts and fruits), root crops and herbs in stratified layers. Livestock, mainly dairy cattle, goats and poultry, are integrated into about 20 per cent of these farms. Economic analyses for 1985-1992 for farm sizes of 0.5, 1.0 and 2.0 acres show that dairying contributes most to gross profits at 31, 63 and 69 per cent for the three farm sizes. Crops were the next most important enterprise (29, 37 and 19 per cent), followed by poultry (22,0 and 9 per cent) and goats (18,0 and 3 per cent). Dairy cattle and goats gave the greatest returns among livestock. Animals made a major contribution to soil fertility through manure and biogas production (de Jong *et al*, 1994).

Intensification of animal production systems

Types and processes

Intensification of animal production systems in Asia differs for ruminants and non-ruminants in respect of species, breeds, scale, extent and impact.

Intensification in ruminant systems is associated with supplies of low cost roughages for which the land base must be adequate. An adequate land base can be achieved through: more intensive use of existing land such as rice bunds in lowland irrigated areas; intensification of crop/forage production systems to form a food-feed system: expansion in land area by use, for example, of lowland rainfed areas and uplands; resettlement; and reallocation of the land use patterns on existing farms. The first three of these options have varying degrees of potential. Expanding land use to include lowland rainfed areas, uplands and even the highlands is possible where there are large concentrations of animals. Increased crop production and therefore feed availability is a major way of intensifying and maximizing animal productivity.

Non-ruminants are less location specific than ruminants and have less reliance on the land base. This subsector is especially important in Southeast and East Asia where there are large capital intensive advanced industries and strong private sector participation. As much as 95.8 per cent of the total volume of pig meat produced in Asia is from China, Vietnam and Indonesia. China, Thailand and Malaysia produce 83.5 per cent of the poultry meat. This level of production is associated with fast economic growth, rapid population increase, demographic shifts (especially urbanization), improvement in socio-economic indicators and demand for animal proteins. The last is reflected in large projected demand over existing supplies. From 1987 to 2006 demand for meat is expected to increase 2- to 5-fold from a base of 31 million tonnes, there will be a 3-to 10-fold increase in demand for eggs from 9 million tonnes, and a 3- to 6-fold increase for milk from a base of 64 million tonnes (ADB, 1991).

Growth, intensification and expansion of the poultry and pig industries have been promoted mainly by market demand but also by financial and commercial forces, private sector participation and operations, access to modern technology and an ability to develop rapidly. The prerequisites for

intensification are opportunities to intensify into large scale vertically integrated production, use of appropriate breeds and strains, feed quantity and quality, processing and storage facilities, good housing, disease control and assured markets both at home and abroad.

Vulnerability

Large intensive units are not without problems and are vulnerable to a number of factors. These include, *inter alia*, the cost of imported raw materials, tariffs, over-dependence on imported technology, breeding stock tied to franchise companies overseas, imported vaccines and regional and international competition in the export trade. The dependence on imported feeds is a particularly important constraint. The cost of feed is increasing in several countries and it is not certain how long the industry will be able to maintain its profitability in the face of this.

Some intensive systems in Asia

Intensive animal production systems in the Asian region include:

- ruminants
 - buffalo and cattle dairy production (India)
 - beeflots (Philippines)
 - sheep fattening (Pakistan, Indonesia);
- non-ruminants
 - pigs (China, Vietnam, Indonesia)
 - poultry (China, Thailand, Malaysia)
 - integrated pig-vegetable-duck-fish

Unlike the intensive single commodities such as beef or pig meat the last example reflects intersectoral production systems which are equally intensive. Detailed results from such systems are not yet generally available but evidence is emerging of their economic viability and sustainability (Congyi *et al*, 1993). The research involved comparison of conventional fish culture with an integrated crop-pig-fish system containing three subsystems of crops (barley and rapeseed cake to feed pigs and fish), fish (for food) and cultivated forage (feed for herbivorous fish). The system was tested at intensive, semi-intensive and extensive levels. The main results were:

- semi-intensive systems had the highest net profit per unit cash input;
- efficiencies of energy and nitrogen use were highest in semi-intensive systems;
- output was 2.6 times production costs;
- positive interactions in the subsystems, recycling of nutrients and economic viability of the integrated system were demonstrably sustainable;
- integrated systems were especially appropriate for resource poor small farms, efficient use of low inputs and development of sustainable agriculture.

One aspect of intensification worthy of comment concerns the use of animal germplasm for pig and poultry production. Breeds now being used are mainly if not exclusively of exotic origin but there could be more effort devoted to indigenous pig, chicken and duck breeds and to traditional systems. Native chickens are favoured locally, often command premium prices and there is an expanding market for their meat. A similar situation exists for duck meat and eggs. The Chinese experience suggests that pigs and ducks have a very important function in integrated systems in humid Southeast Asia and in the development of sustainable production systems.

The second aspect of intensive production systems is related to the implications of the GATT agreement. Opportunities to increase production for the export market will become more attractive

with the removal of subsidies. Beef from Philippine feedlots, for example, will have potential markets in Hong Kong, Japan and elsewhere. Key determinants of success, however, are efficiency of the production process, an ability to keep the cost of production to a minimum, and maintenance of strict animal health and hygiene standards.

Priorities for research and development

Opportunities for research and development to overcome existing constraints are enormous and the contribution of animals can be greatly enhanced. In order to achieve this, however, a reorientation of programme focus and direction is necessary, using multidisciplinary strengths in target agroecological zones. Such programmes have the potential to demonstrate sustainable production systems, increased productivity and environmental protection.

Mixed farming systems

In general, holistic research on mixed farming systems involving crops and animals is weak and most past research in Asia has been on cropping systems. The inclusion of animals in mixed farming systems research began as recently as 10 years ago in some countries. Some progress has been made in the development of methodologies to understand the interactions between subsystems but much of the work has been sporadic and has not yet been tested on a large scale. Observations relevant to research on mixed farming systems are:

- there is a paucity of information on methodologies and results;
- there has been limited work focused on specific agroecological zones;
- there are inadequate methodologies for crop-animal systems compared to crop systems and mixed systems research is relatively new;
- non-ruminants have had less attention in integrated systems because of the priority given to ruminants by most governments;
- strong multidisciplinary efforts are a prerequisite to research and development of mixed farming systems;
- increased focus needs to be given to rainfed agroecological zones in view of the complexity of these areas and the natural resource management issues; and
- increased investments for research on mixed farming systems in priority agroecological zones will provide major benefits and contribute to development of sustainable agriculture.

Research requirements in support of crop-livestock-tree systems in Asia are suggested to be: baseline studies to quantify energy flows; simulation studies to identify possible coefficient changes in the system; field testing of possible interventions and new technologies; and "test marketing" of proposed developments on representative subpopulations within the region. It is further suggested (Timor, 1992) that such studies need to be carried out across national boundaries within ecoregions.

Better use of animal genetic resources

Better use of animal genetic resources is necessary to maximize productivity. Animal development programmes in most countries have tended to emphasize one or two sectors. Dairy production has received major attention in almost all countries mainly because of its ability to generate quick income for poor people and produce precious animal proteins. Dairy development has had varying degrees of success but is hampered by yield-reducing environmental stresses, inadequate feed production and poor nutritional management, high capital costs; limited market size, low cost of competing imports and product perishability. Investment in these programmes has been enormous but returns are essentially short term and long term viability is very doubtful. An associated inability to sustain breeding and maintenance of crossbred animals to support these programmes is a further problem.

Such massive use of resources has diverted attention from more balanced development and use of other species to increase protein production. Notable in this regard are beef cattle, swamp buffalo, goats, sheep and ducks. Implicit in this observation is that many potentially important breeds have never been adequately used and in many cases are destined for extinction. Ironically, FAO's global animal genetic data bank indicates that Asia possesses 38-84 per cent of the total number of breeds in various species (63 buffalo, 200 cattle, 147 goats, 231 sheep and 142 pigs) but it is doubtful if most of these are fully used in commercial terms. Future development of currently underutilized areas, such as the rainfed ecosystems, must involve concurrent and more effective use of many of these breeds.

Intensive utilization of feed resources

Increased intensification and efficiency in the use of feeds is most important. Feed is the principal constraint among the non-genetic factors affecting productivity. Ruminant feed resources are greatly underused. Feed availability from native and cultivated grasses and roughage by-products in Malaysia is about four times in excess of requirements (Devendra, 1982). More recent calculations for the Philippines indicate that the available feed can support six times the current ruminant population. The situation is similar throughout Indochina. Better use of available feed is hampered by low animal numbers, inadequate intensification of the production system and poor technology delivery and use.

In areas such as Mongolia where livestock are the basis of the economy and the production system is largely pastoral, increased fodder production is necessary as are corrections to problems of mineral deficiencies. Research into these and other constraints provides a major challenge for rangeland ecology and national livestock production (Falvey and Leake, 1993).

Within different ecosystems different types and quality of feed are available but the general principles of feeding and management are the same. The approach should be towards a balanced feed supply, with balanced energy/protein ratios and correction of critical deficiencies with low cost supplements.

Improved technology and use of research results

Inadequate, inappropriate and inefficient use of the available technology is a major limitation to increased animal production. Technology application at farm level is particularly weak and is related to a combination of poorly formulated development programmes that often preclude strong interdisciplinary team effort and concerted on-farm use. The use of research results therefore merits very high priority. Large scale on-farm testing is needed and will involve a major shift to participatory development. Intensification and efficient resource use will determine the extent to which traditional systems can be transformed into market oriented enterprises with their attendant benefits.

Research investment in rainfed areas

Investment in agricultural research usually produces high rates of return. The benefits from high yielding cereals is one example. Parallel evidence for animal production systems is scanty but this imbalance needs to be corrected through increased investment. Focusing research on commodities is no longer enough and it should now be expanded to crop-animal systems especially in rainfed areas. Because of the complexity of research and development in the rainfed lowlands and uplands resource management will need to be more holistic. Costs will be higher but returns for the contribution of livestock are likely to be much greater in the future.

Animal diseases

Disease reduces animal productivity and causes economic loss. Important diseases of ruminants are foot and mouth, rinderpest, haemorrhagic septicaemia and anthrax. Swine fever is the main disease of pigs and Newcastle disease is a serious problem for poultry. Tick-borne diseases including theileriosis, anaplasmosis and babesiosis are endemically stable in indigenous Asian animals but cause loss and mortality in imported and improved stock. It is estimated that tropical theileriosis causes an annual loss of US \$ 800 million in improved cattle in India.

Other infectious and non-infectious diseases also lower animal productivity. These include internal parasites such *Fasciola gigantica* in all ages of buffalo and cattle and *Haemonchus contortus* and *Trichostrongylus* spp. in small ruminants. Other diseases include brucellosis, contagious pneumonia and mineral deficiencies.

Animal health services account for about 80 per cent of Government support to the livestock sector and there is substantial donor aid in this field (ADB, 1993). As most endemic diseases are under workable control, the main role of governments should be in vaccination and prevention of epidemic diseases such as rinderpest. Training of farmers in basic animal hygiene should also repay investment.

Institutional issues

Key institutional requirements are:

- commitment to interdisciplinary research, a systems approach and sustainable development, these being especially important for integrated research and development in specific ecosystems;
- formulation of research programmes with production and postproduction components and community based participation in response to the real needs of farmers;
- institutional and structural commitment that are programme-led and programmes that are needs-led; and
- promoting effective interinstitutional coordination and collaboration for decision making, management, dissemination of practical technical information and resolution of feedback issues.

Policy framework

Successful implementation of projects needs strong policy support. A reorientation of animal production programmes is required to deal with more complex multisectoral and multidisciplinary projects that address natural resource use and management and that provide for environmentally sustainable development. Some factors to be considered include watershed management, nutrient recycling, biodiversity, changing socio-economic conditions and attitudes, and consumer preferences.

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Discussion sessions: Part Three

[Redesigning for risk: tracking and buffering environmental variability in Africa's rangelands](#)

[Mixed farming systems in sub-Saharan Africa](#)

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Redesigning for risk: tracking and buffering environmental variability in Africa's rangelands

Discussion Summary

The role of research was the main focus of discussion. There was general agreement on the need for policy research and that institutions such as ILRI have a comparative advantage in undertaking surveys among systems. The concepts of "tracking" and "buffering" raised comment and required clarification. Land reform and tenure were discussed with a consensus that widespread agrarian reform for communal areas is neither desirable nor feasible but that there is a need explore other forms of tenure that allow for greater control of "key" resources such as dry season grazing.

Tracking and buffering

The comparative advantage of institutions such as ILRI in doing the types of activities identified in the paper needs to be clearly identified, with which partners they should do it and the process mechanisms that need to be established (Peters). This relates in part to earlier discussion on research funding. It also seems it is now time to make intelligent interventions in agropastoral systems rather than just doing research. One possibility would be to have a scientific component in all projects while viewing the actual implementation as an experiment and the overall project as a trial. The limit for speculation about what is likely to happen has probably been reached and it is now time now for action (Behnke).

Tracking must be related to mobility in space and over time and to the question of security. The importance of scale and distance in tracking needs to be known. The main problems seen by pastoralists are: the adverse terms of trade in which livestock prices are too low and goods and services are too high, and inaccessible range due to security problems and disputes. Many current problems are politically based and poor security will limit the ability to do tracking (de Leeuw). Tracking would be both temporal and spatial. Monitoring of markets would be one indicator but many of these are imperfect and affected by government (which is usually counterproductive) and often, inadvertently, by donor policies. Security can be a serious problem and is often politically based: if there were greater "economic attachment" to a particular country security might be less of a problem (Behnke).

Participation and ownership

Producer "ownership" of a project in which they are involved in identifying the problem as well

as the solutions helps in management of risk. The views that are presented need to be reconciled with farmers' interests (Nana-Sinkam). There is probably only a small overlap between the perceived needs (wants) of pastoralists and what any programme of tracking and buffering could or should provide: only those items that are appropriate should actually be provided (Behnke).

The role of pastoral organizations needs to be defined (de Haan). The focus on these has mainly been in West Africa in recent years: reviews seem to indicate that they have been expensive to establish and have not always survived when external funding stops. Traditional associations are models that should be considered (as they have been in West Africa) (Behnke).

The adverse effects that the research driven ranching model has had on pastoral development have been described. Should pastoralists be concerned if ILRI ignores the problems identified or should they be strong advocates of the ILRI programme in this area (Young). Pastoralists would not distinguish ILRI participation from that of government and would give it a sceptical reception (Behnke).

ILRI does not have a mandate to intervene in ranching model systems but it does have a comparative advantage in working across different pastoral systems, in looking across time and in taking a global view and drawing conclusions from those comparisons and the rapid changes that are taking place (Fitzhugh). There is no disagreement here and, in addition, the benefits may go beyond the pastoral sector so that the approach could be used to examine related systems (Behnke).

Sustainability and environmental impact

Sustainability includes accounting for environmental deterioration and the consequences of economic activity. Care needs to be taken of the cost in environmental impact of these economic activities and rates of return or profitability figures may not reflect reality (Nana-Sinkam). Environmental impact must be measured by biologists but if economic parameters of impact assessment are needed, given that trend data masks the intrinsic instability common to these systems, then modelling (with all its failings) is probably the best available tool (Behnke).

Land reform and tenure

Land reform may be important in development (de Haan). The future is not in widespread agrarian reform, which usually implies individual ownership, but in a complex mix of individual and communal tenure. It is important that pastoralists are allowed to control key resources such as dry season grazing areas and water. Control varies from very strict individual ownership to open access and largely depends on the importance or value of the resources in question. Total "communal resource management" is not realistic, however, where very valuable resources are involved and some regulation may be needed here (Behnke).

ILRI has a role in research on tenure, especially comanagement (Young).

Mixed farming systems in sub-Saharan Africa

Discussion summary

Discussion focused on the likelihood and impact of intensification including competition for land and labour. New technologies were considered important in the intensification process although the poor past performance of "technology transfer" and the lack of research relevance were noted. There was no consensus that integration and intensification is the only way forward and it was pointed out

that many arable farmers do not own animals and those who do may not necessarily have the incentive to integrate or commercialize. The need for characterizing integrated farming systems by various economic, environmental and social indicators was discussed.

Competition for land and labour

Further comment is needed on competition for labour and land in the intensification process. Management and labour skills should be considered when formulating and testing or developing mixed farming systems. Scientists should focus more on how a farmer can move between systems if the alternatives are more appropriate to their needs (Ostergaard). Land and labour competition will vary according to the level of intensification (Saleem).

Mixed crop-livestock systems will continue to intensify and result in higher output and income but this can only happen in an environment characterized by rapid urbanization which raises the opportunity cost of keeping cattle for traction or for purposes other than meat and milk. Rises in beef prices can adversely affect mixed crop-livestock systems this being the same effect as when crop prices are low. The role of policy related to mixed systems needs to be seriously considered (Ehui).

Guiding the dynamic development of mixed systems will require farm analysis and comparisons between enterprises in terms of efficiency and economic returns. ILRI may want to look at the importance of these methods which should have greater importance in NARS (and other partners) in order to improve research and extension activities, farmer participation and overall linkages within the system (Peters).

Systems definitions

A "mixed farming system" needs to be defined: based on the proportion of subsistence and/or income from livestock or on the level of interaction including manure, traction, fuel and other exchanges. In crop-livestock communities there are many poor farmers (in terms of livestock) and by focusing on livestock ILRI may be excluding the poor and favouring the rich (de Leeuw). A definition of "mixed-farming" may not be required but it is an integration of distinct activities that can range from predominately crop to predominately livestock orientated. A basket of interventions (technologies) is required to cover varying situations and there is no one technology appropriate to "mixed farming" (Ehui).

Attempts should be made to characterize systems by various indicators such as ecological (balance of N. P. K and flora), economic (household income and stability over time), and social (education of children, family life and quality of life) (Ostergaard).

Participation, technology transfer and research relevance

ILCA had a long history of research on single animal draught work. Uptake has been poor and the relevance of the technique to the target population needs to be considered (Wilson). The correct issues may not have been tackled in the past but changing economic circumstances may now lead to a better uptake: intensification, the need to reduce grazing pressure and sustainability issues are now better understood by farmers (Shapiro).

Separation of livestock and crops, especially in the supply of services such as extension has been indicated. Research progress is also limited by the narrow (usually cultural or disciplinary based) views taken by scientists, an example being plant breeders failing to take account of by-products (Toutain). ILRI has always adopted a multidisciplinary approach to livestock research (Saleem).

Disease control in intensified systems demands better management and is dependent on

farmer education. Responsibility for this probably resides with agencies other than ILRI. Epidemiological studies might reveal specific constraints such as extended calving intervals that could be overcome with simple technology such as heat detection tests (Ole Nielson).

Specific problems related to intensification include:

- sociological ones where cropping and livestock are done by groups of people with different social and ethnic backgrounds who are unwilling to integrate;
- lack of a maximum profit motive leading to lack of incentive to intensify; and
- low population density in many rural areas means land is still available leaving farmers the option to move to new areas when soil fertility declines rather than developing integrated systems (Baker).

The potential of new technology should not be underestimated. There is nothing sacrosanct about mixed farming systems as they are dynamic and subject to change. Increasing population will lead to demand driven intensification and the need to adopt improved technologies. The issues are to identify opportunities, assign priorities and intervene to ensure a successful transition. The erroneous view that production has not increased in sub-Saharan Africa over the last 20 years should be discarded. Production has increased by about two per cent per year overall even though per caput production has declined. Not all of the increase in production has been due to yield increases per unit area and much has been due to area expansion. There have, however, been major technological successes with food crops such as maize, as well as cereals in cotton rotations. Mixed farming as a model of development, as presented in this paper, is helpful but does not go far enough. Mixed farming is not an end in itself. If it is treated as such it will only lead to further development failures. A model is needed that will help to identify alternative strategies to bring about agricultural development. The mixed farming model is basically the conservation model and one that makes improved integration of crops and livestock the goal. This conservation model has been able to achieve only low productivity increases of about one per cent per year but about four per cent is needed to achieve increased agricultural output in the face of three per cent population growth. The required model is the intensification model of Boserup and others based on the premise that increased population pressure leads to decreased land availability and quality and decreased opportunity cost of labour but increased market opportunities. These factors motivate farmers to intensify via land saving cash inputs. Mixed farming is thus inadequate as a development model for identifying potential change. The intensification model includes the possibility for improved crop-livestock integration but also intensified mixed systems as well as intensified or low input specialized systems (such as agropastoralism) and is what must be used as the conceptual model for development (Shapiro).

Livestock feeds and mixed farming systems in West Asia and North Africa

Discussion Summary

There was considerable discussion on the sustainability of many of existing practices, particularly the use of subsidized feed grain and its consequences. The future for many countries in the area is bleak especially those lacking a potential manufacturing base or mineral wealth. Self sufficiency in grain or animal products is unlikely although rotations incorporating legumes, on the little evidence available, might increase overall production and have the additional effect of increasing the amount animal feed. Considerable interest was expressed in the survey methodology used by ICARDA and its potential for use by NARS.

Participation, uptake and research relevance

Even where there are no lentils in the rotation the use of annual *Medicago* spp. has been limited. It would be useful to know why the introduction of grain and/or forage legumes in crop rotations has not had greater uptake. One reason is that the harvesting of grain legumes is labour intensive and labour in the region has a high opportunity cost. The future for grain legumes is, however, brighter than for forage legumes as the increasing population will not be able to afford to maintain the already low consumption levels of high value animal products and pulses become increasingly more important in human diets. The future of livestock will depend to a great extent on pricing and import policies. If, however, self sufficiency remains a regional objective, especially for wheat, then livestock production may benefit as a change from continuous wheat monoculture to rotations that include grain and forage legumes will provide valuable additional animal feed.

The effects on water use efficiency and ground water reserves are important. Technology that is likely to increase leaf area indices and evapotranspiration may be undesirable (Saleem). Farmers basically only care about the value of production and do not take a long term view on the value of water (Nordblom).

Two clusters of countries with respect to population growth and economic situation were presented. It would be interesting to know how this clustering is used in research programming (Peters). The stereotype of an oil rich Arab state is not representative of the region which comprises typically poor countries with agricultural economies: the latter group is the focus of ICARDA's programmes (Nordblom).

ICARDA's capacity for microeconomic systems analysis has been demonstrated. Presumably these results are used in research programming and in improving the capacity of its partners in improving information systems, farm analysis and the setting of research and extension priorities (Peters). Most of the rotational trials have been undertaken by associated national programmes. The methodology is being used by NARS but is still at an early stage (Nordblom).

Policy

Subsidized concentrate (grain) feeding must be having some effects on the rangelands in the region (de Haan). The effect is generally negative since this kind of supplementation allows animal numbers far in excess of range carrying capacity to be maintained. Range grazing may represent only a relatively small proportion of the diet but the large increase in animal numbers is causing the damage (Nordblom). Livestock pressure on the rangelands is compounded by the large mother flocks needed to supply male stock to the feedlots (T. Lahlou-Kassi).

The population challenge is clearly critical to any assessment of the type of research to be carried out. A description of the key elements in any scenario to feed the expected 2020 populations would be very useful (Young). Wheat prices are expected to remain low and will be the staple diet of the increasing population although neither grain nor animal product self sufficiency is likely. The prospects for those countries that do not develop a manufacturing base or have mineral wealth remains bleak. Demand will not be related to either "want" or "need" but to disposable income, that is, to effective demand (Nordblom).

Mixed farming systems in Latin America and the Caribbean

Discussion Summary

Discussion centred on what many participants obviously considered controversial

matters introduced by the speaker. There was concern in particular about remarks that extension workers were not needed as farmers acted as their own extension agents and about the need to avoid continuing with farm surveys over long periods of time without them achieving any tangible results. The amount of information available and its accessibility and transfer were also major points of discussion.

Extension and surveys

It does not seem possible to work with farmers without extension agents (Oram).

The statement about "no more surveys" is alarming. On-farm epidemiological surveys are useful in identifying determinants of health and productivity. This method can identify practices that farmers use to improve performance as well as identifying the most important constraints needing research. Measuring performance improves performance (Ole Nielsen).

The statement that no further surveys are needed is very surprising. It is not possible to disseminate and then monitor the effects of dissemination of new techniques without using surveys (Lahlou-Kassi).

Information systems and delivery

There should be concern about information overload. It is now becoming difficult to find the germs among the large volumes of information that add little to knowledge. Some hints for solving this are needed. More effort needs to be given to the way communication is done to avoid too much repetition (Young). There is inadequate information in most areas and if there is too much elsewhere it would be interesting to know about it (Peters).

Information systems are very important but there is much dissent about what systems are needed. Information systems must be separated from data bases. Resources to do the literature reviews, screening and translation indicated in the paper are probably not available (Oram).

One of the main constraints to improving productivity is failure to apply existing knowledge but this is a problem that must be tackled (Irvin).

The responsibility of the education system should be taken very seriously and the argument could be expanded. International agricultural research systems have to think about how to overcome the linkage problem and the overall efficiency of research and extension. In comparison to industrial research systems public research has too many networks without a problem orientation and delivery mechanism involving all partners of the research, extension and education systems. IARCs need to be concerned with this since final success will depend on the efficiency of research, extension and education generation and delivery (Peters).

Participation

There is much talk of farmer participation. This is important but in reality, when two sets of farmers are contacted from the same village, they come up with totally dissimilar problems. There is a need to find some commonalities about topics for international research (Saleem).

Markets are talked about in very abstract terms. There is a need to specify whether these are external or internal and, if the former, it would be interesting to know how the Third World can compete with the rest of the world and its formidable propaganda machinery, news media, quality impositions, ridiculous standards [sic!] and money power. Perhaps, for example, preferential treatment or territorial market-producer relationships should be encouraged for the developing countries (Saleem).

Mixed farming and intensification of animal production systems in Asia

Discussion Summary

The complexity of Asian systems was a major focus of discussion. Non-ruminants are very important in Asia and may need more research. It was agreed that conventional and non-conventional systems are evolving rapidly in response to population growth and urbanization. It would be useful to have much more information on the extent of the positive and negative (including the generation of waste) changes taking place.

Urbanization and economic growth

There is rapid economic growth. Urban incomes and demand for food and animal products are high and rising in many Southeast Asian countries. It would be interesting to know why the farming community is not benefiting from investment of off-farm income in farming, especially through family connections in both sectors (de Leeuw).

Some consequences of urbanization are increases in "waste" production including water effluent and sewage, human food waste and waste from agricultural and food processing. Instead of considering these as wastes they could be regarded as potential resources for improving livestock/crop production systems in periurban areas. In this respect they are worthy of further research (Irvin). Wastes can, however be dangerous, as are water in China and manure and tannery effluent in India (de Haan).

Development and change in farming systems

Mixed crop-livestock farming with ruminants and non-ruminants has been identified as very important in Asia. This perhaps suggests that the emphasis on ruminants should be changed and that when non-ruminants are components of a production system of interest they should of necessity be studied as part of the system (Osuji).

More needs to be known about the structure of land size and ownership and, especially for tree crops, how much is owned by individual farms and how much by commercial companies (Oram).

It seems that in countries with rapid economic growth and growing demand for animal products there is a trend towards specialization. More should be known about intensive pig and poultry production in Southeast Asia and changes in size of production units. Integrated farming systems that have an aquaculture component should be covered by the ICLARM aquaculture farming system network in Southeast Asia (Peters).

Mixed and intensified systems have been discussed but not the so called landless systems that are common and increasing in Asia as source of animal food. We need to know the reasons for this development and about interactions with other systems (Maki-Hokkonen).

Part Four: Working group sessions

Sub-Saharan Africa and West Asia and North Africa

Chairman

Kurt Peters

Rapporteur

Roy Behnke

Asia

Chairman

Michael Young

Rapporteur

Dev Devendra

Latin America and Caribbean

Chairman

Lucia Pearson de Vaccaro

Rapporteur

Tony Irvin

Final Plenary Session

Chairman

Michael Young

Rapporteur

Timothy Williams

Working group one: Sub-Saharan Africa and West Asia and North Africa¹

[Task One](#)

[Task Two](#)

[Task Three](#)

¹ The participants in this group were: K Peters (Chairman); R Behnke (Rapporteur); O Badiane; B M Bakar; P N de Leeuw; S Ehui; A Lahlou-Kassi; S C Nana-Sinkam; T L Nordblom; P Oram; E O Oyedipe; B Toutain; R T Wilson; T Williams

Task One²

² Working groups were assigned three tasks. Task One was to review changes that have taken place in the supply and demand for livestock products over the last 30 years, including directions in input use, resource management and degradation and to identify the underlying factors causing these changes such as macroeconomic policies, institutional factors, trade, urbanization and population growth. The output was expected to contribute to a report on past and present directions in livestock productivity and consumption of livestock products as part of a forward looking 2020 vision paper to be produced later

Sub-Saharan Africa

The discussion opened with a debate on how to deal with regional diversity. A grouping of countries by agroecological zones was suggested but some felt a need to get closer to factors driving system changes such as population density and growth, the overall economic situation and the livestock feed situation. It was agreed that development prospects and not just the ecological base must be taken into account in setting research objectives. In addition, a pure ecoregional breakdown is crosscut by economic development indicators such as the contribution of the agricultural sector or livestock subsector to GDP. Generally low incomes across sub-Saharan Africa, however, make clustering by economic indicators less informative than it might otherwise be.

General trends

Trends have been away from extensive and mobile range systems towards more intensive and sedentary small holder agropastoral and mixed farming systems in respect of both large and small ruminants. Livestock numbers are increasing in the wetter areas and decreasing in drier areas because transhumant herders have moved south and settled while local farmers have incorporated ruminants into their farming systems. Small ruminant numbers have increased relative to cattle over the last decade in West Africa.

Research, extension and agricultural education

Some data are available on research and extension funding, human resource situations and levels of training but there is no political lobby or domestic constituency for long term

agricultural research programmes. This problem is especially acute in sub-Saharan Africa. Structural adjustment has improved the receptivity and visibility of policy research but budget cuts associated with structural adjustment have had a negative effect. Linkages between research and extension are generally poor. Vocational training and farmer education requires strengthening although some countries such as **Kenya** and **Nigeria** have made a start. The demand for and supply of various kinds and levels of training need analysis. The use to which people are put after training also needs to be clarified.

Resource management and degradation

It is not possible to state a trend until a workable definition of degradation is agreed. One participant considered soil nutrient depletion an important criterion. If this is accepted degradation on cropped lands may be serious but will be much less so on grazing lands. Awareness of natural resource management problems is improving (especially in national research organizations) and there are now some good case studies of local community land management. NGO interest in this area is high but their effectiveness is unpredictable because they have no appropriate technical knowledge.

Policy impacts

Devaluation of the CFA franc in January 1994 had both positive and negative impact on livestock production. It had a negative effect on high input, intensive, import dependent systems but favours systems based on domestic natural resources. Some apparently negative impacts of devaluation may be necessary corrections of policy induced distortions. Anti-agricultural trade, marketing and exchange rate policies have begun to change. These reforms have already had an effect on trade [see paper by Williams *et al* in these Proceedings]. It is hoped to see production responses and not escalating prices. Badly conceived domestic sectoral and trade policies can offset the benefits of devaluation.

In **East and Southern Africa** the contradictory objectives under which parastatals operated - they were obliged to make a profit while simultaneously serving consumer and producer interests - thwarted performance.

Correlations between land tenure reform and changes in agricultural output are weak in sub-Saharan Africa. Other constraints to better agricultural performance are more important than deficiencies in land laws.

West Asia and North Africa

General trends

Livestock product supply in WANA is generally well below demand. Most countries are net importers of livestock products with subsidies for local producers. It is not wise to generalize, however, and **Tunisia**, **Morocco** and **Algeria** have different policies for the import of milk powder with the last being a massive importer. **Sudan** and **Turkey** are the exceptions to the general pattern of import dependence.

Socio-economic and development indicators

Income growth is suggested as a useful criterion of economic development with respect to livestock. The share of GDP derived from agriculture is good [information on changes in input use, population, literacy, life expectancy, importation of livestock feeds and some aspects of macroeconomic policy relevant to livestock are in Nordblom *et al* in these Proceedings].

Policy issues

Turkey, **Jordan**, **Morocco** and **Tunisia** are committed to or attempting to implement

structural adjustment programmes whereas **Libya, Syria, Iraq** and **Iran** are resisting them. In general, however, there is continuing devolution from the public to the private sector.

Rangeland tenure policies vary by country although there has been a general trend towards privatization. Government has asserted its authority on tenure in **Syria** and tribal authority has been rescinded: unfortunately nothing has taken its place and there is now *de facto* open access. **Jordan** supports tribal authorities in control over animal movement but some problems are emerging with urbanization and privatization of rangeland. Large scale invasion of rangeland by olive and barley cultivation is occurring in **Tunisia** where the government is about to set up a new commission to study land allocation in low rainfall areas. A new land law is about to be promulgated in **Morocco** where an attempt to set up communes with territories which overlapped or cut across old tribal territorial boundaries resulted in ambiguity and conflict. The respective responsibilities of the Ministry of Agriculture and Agrarian Reform and of the Ministry of the Interior also cause confusion.

Most WANA countries have been through politically motivated land reforms that have been variously effective but which have usually involved the breakup of large holdings. Many holdings are now uneconomically small and fragmentation is a serious problem. It is difficult to rectify this situation as it still is not easy to sell land in many countries. Large state owned livestock operations have usually failed and land is being transferred to the private sector.

There are production quotas for several critical crops but movement and sales controls are now being removed from parastatal institutions. In many countries, however, fertilizer and machinery sales and distribution remain the purview of government.

The impact of irrigation on livestock production differs with the type of irrigated farming system, of which there are several in WANA. The primary effect is through fodder crop production and the use of crop residues [data on fodder and residue use are to be found in Nordblom *et al* in these Proceedings but no distinction is made between the contribution of irrigated and rainfed agriculture].

Credit

Availability of credit has promoted livestock production.

Research, extension and agricultural education

Extension services are weak in technology transfer and often serve as state agricultural police. There are some signs of improvement especially in the **Maghreb**. Expenditure on agricultural research in relation to GDP is low. There has been a major increase in literacy in the last 20 years but this is still low by western standards.

Infrastructure and marketing

Roads and railways are generally better in WANA than in sub-Saharan Africa. There are regional organizations and some potential for regional market integration in the **Maghreb** and the **Gulf** states but there is generally not much current activity.

Task Two³

³ Task Two was to identify the key goals and opportunities for livestock development in the next 25 years and by major agroecological zones and to identify the major social, economic, environmental, technical, policy and institutional constraints to achieving these goals. The expected output was a clear statement of defined goals and opportunities for livestock development that can realistically be achieved by 2020 and a related description of the set of concerns

and constraints that must be overcome for the goals to be achieved

Sub-Saharan Africa

Development prospects over the next 25 years

In general these seem bleak without fundamental policy reform and technical innovation.

In the **arid** pastoral zone beyond the limits of cultivation (excluding irrigation) the human carrying capacity can be increased through trade.

The importance of small ruminants is likely to increase with increasing population pressure and declining farm size in the **semiarid** zone. There are large concentrations of cattle in this zone but no commensurate level of milk production. There is potential for increased dairy production but appropriate policies are required. Some fattening operations can be expected to develop where feed is available.

There are prospects for both expansion and intensification in the **subhumid** zone. Cattle will take precedence over small ruminants but the livestock product output mix will depend on prices. As there is little demand for animal traction in root cropping systems there are fewer possibilities for integration of livestock except for feed and labour use. There is potential for expanded maize production and for its increased use as animal feed. Greater areas of crops will have a negative impact on migratory livestock producers in this zone who will tend to settle. Tsetse flies will decline in importance as cultivation spreads and *Bos indicus* zebu cattle will assume more importance at the expense of the trypanotolerant *Bos taurus* types.

In the **humid zone** it is likely that crop-livestock integration will be limited to economic links. Poultry and pig production is likely to expand. There is no cultural attachment to livestock, especially ruminants, and the disease challenge is high but there is good potential if the considerable health and management problems can be overcome. The main consuming areas are in the humid zone which therefore has a comparative advantage for final fattening near urban areas but there will be a need to control any possible environmental pollution.

There are possible resource degradation problems in **semiarid and subhumid East Africa**. Crop areas are reduced here because of bimodal rainfall. Soils are better than in West Africa so nutrient depletion is less of a risk but slope and wind erosion may be problems. The bimodal rainfall pattern allows pastoralism to penetrate deeper into relatively high rainfall areas. Subhumid lowlands in **Tanzania, Mozambique** and **Angola** have low population density and high potential if tsetse problems can be overcome. Civil war has been a problem for many years. Root crops are expanding in these areas which may limit integration possibilities. There is potential for intensive livestock production in **Zimbabwe** and for small scale pigs and poultry in **Southern Africa** in general.

The **highland** areas can be considered as a series of subzones. In the "roots and beans" highlands of **Rwanda, Burundi** and eastern **Zaire** the demand for livestock products is limited by low purchasing power of consumers and continued civil strife is a problem. In the **Kenya** "dairy" highlands land is the scarcest production factor but further specialization in the vicinity of urban areas can be expected. Dairy production may then be squeezed out of these areas, but total milk output is likely to remain constant as dairy production shifts to more peripheral areas. Temperature is the limiting factor at high altitudes in the "grain" highlands of **Ethiopia** where extensive sheep grazing predominates. There are prospects for more efficient sheep production through fattening. Dairy production is likely to replace the oxen/cereal system at middle altitudes as farm sizes become smaller.

Areas of concern and key constraints

The major causes for concern are general matters of security at the local level, especially those between pastoralists and crop farmers over crop damage and competition for scarce resources, and civil war on a wider scale. Human health problems and imperfections in the marketing system are additional problems. Concerns about animal welfare and the environment will assume increasing importance as will the various policy and institutional constraints that have been covered during the course of this Roundtable.

West Asia and North Africa

General goals

A major goal is to exploit the comparative advantage presented to livestock by crop residues and native pastures and the integration of forage crops, feed grains and agroindustrial by-products in livestock diets. Nutritional management of small ruminants should be improved to avoid feed wastage and to make better economic use of animal genetic potential. Expansion of meat, dairy and poultry production based on domestic and imported feed grains and agroindustrial by-products should take place where there is a comparative advantage in so doing

Constraints

Distortions in exchange rates prevent a clear view of the real benefits to be gained from comparative advantages. The institutional framework for the most appropriate management of rangelands is missing.

Development prospects over the next 25 years

The West Asia and North Africa region is the biggest importer of livestock and livestock products in the world. It will remain dependent on imports - and will be a major potential market for sub-Saharan Africa -for the foreseeable future. It is not clear whether or not intensification will have a negative impact on the natural resource base. If rangeland output is to be increased above current levels more appropriate institutional arrangements are needed. There are prospects for intensifying existing mixed farming systems through the use of external feed resources and forage crops. Intensive horticulture may, however, compete with intensive livestock production for capital and scarce natural resources.

Role of the livestock subsector

There is considerable potential for increased milk production if suitable policies are put in place. More intensive production will increase the absolute value of livestock output but livestock's contribution to GDP may show some decline.

Goals for the livestock subsector

These should be to exploit comparative advantages and to remove policies that act against these advantages.

Areas of concern and key constraints

There is no unused land and no possibility of horizontal expansion. Increases in output must come through intensification and larger irrigated areas.

Task Three⁴

⁴ Task Three was to identify the appropriate strategies for the goals identified in Task Two, including actions on-and off-farm at the national level and at regional

and international levels, in order to improve livestock production and the research and development implications of these actions. As far as possible the temporal, spatial and social implications of these actions were to be indicated. The expected output was a clear formulation of the measures required for achieving better management of the natural resource base to 2020

Sub-Saharan Africa

Low potential areas: Arid and part of bimodal rainfall semiarid zones

There is some need for development and employment of both existing and new *technology* but *policy* and *institutional* factors are of much more importance.

High potential areas with good development opportunities: Semiarid and subhumid zones and part of highlands

All of the *technology policy* and *institutional* spheres are in need of very strong support and returns to investment in these areas should be very high.

High potential areas with poor development opportunities: Part of highlands with high population densities

All of the *technology*, *policy* and *institutional* spheres are in need of strong support. Returns to investment in these areas should be reasonably high.

Agribusiness

There is little need for *technology* or *institutional* support but the *policy* area needs clarification.

West Asia and North Africa

Arid zones (< 200 mm): Range and pastoral mountain systems

In terms of *technology* focus known techniques should be used to arrest degradation and possibly to increase productivity. These techniques include resting, rotational grazing, use of shrubs and the application of phosphate fertilizers. There is also a need for better characterization of rangeland areas and their potential under various management regimes.

Under the heading of *policy* requirements there is a need for clarification of property rights and steps must be taken to establish appropriate communal or private management systems. There will probably be more privatization in the long term.

There is typically weak *institutional* capacity at the national level and political and legal issues are not well understood. The potential for social conflict requires mediation and interministerial collaboration. Partnerships between IARCs and NARS on strategic issues related to short and longer term interactions between technology and policy are essential to the development of sustainable management.

Semiarid zones (200-450 mm): Cereal-legume mixed farming

These main crop-livestock zones are currently dominated by wheat and barley. The *technology* focus on the introduction of legumes, and especially forage legumes, has had limited success. Adoption rates for seed and fertilizer technology for barley production have been low. Sheep are the key enterprise on many farms. The main focus should be on economic integration for the optimal nutritional management of small ruminants.

Policy must focus on integration of cereals and legumes with small ruminants. Strategic research is needed on price-subsidy relations, structural adjustment, comparative advantage and factor availability. The impact of changes to support policies for wheat or livestock, barley and forage systems must be taken into account as must that of rising labour costs.

The **institutional** capacity of NARS must be strengthened. Governments provide too little funding to research and must allow NARS to assume greater responsibility. The effort devoted to management and nutrition of small ruminants should be increased to bring it in better balance with existing efforts on animal breeding and veterinary services. There is a need for more coordination of technology and socioeconomic and policy research. IARCs must work together on policy, trade, price and factor availability issues to balance long term strategies against social disfunctions due to sudden policy changes.

Subhumid zones (450-1200 mm)

Irrigated areas are a small proportion of the total cultivated area. This is the zone of greatest land use diversity with emphasis on winter wheat, horticulture and industrial crops. It is also the main area for agribusinesses in the form of intensive dairy, feedlot and poultry enterprises. Migratory sheep flocks enter the zone to graze stubbles, fallows and by-products.

Long term **technology** issues are partly related to the management, scarcity and competition for water in and among sectors and states. There is potential pollution of the environment by agroindustries and feedlots. The implications of rapid population growth and urbanization on labour availability and the type of enterprise or system are important. Current technology and knowledge is adequate for short term management of resources through NARS. There appears to be no major need for IARC involvement.

In the **policy** area there is a need for greater emphasis on strategic issues affecting resource use and on the price, trade and input policies affecting the choice of enterprises. Attention must also be given to import and export issues and to markets for horticultural products within the GATT framework and in the European Union and the Gulf states. The scope for integrating crops and livestock within and across ecozones and farming systems and within existing land use patterns must be further defined.

The **institutional** needs relate to:

- integration of livestock with crops and rangeland across systems;
- inadequate links between research and extension for technology transfer and evaluation of impact, farmer preferences, social issues and feedback to policy;
- the need to develop effective mechanisms for people participation in improved range production and to determine preferences for technology elsewhere;
- encouragement of appropriate privatization of services while considering who should do strategic research on major animal diseases;
- seed deficits; and
- macroeconomic distortion.

Highland areas

Cold winters and transhumant livestock management compound **technology** problems.

Integration with the remainder of the region to assist trade and poor infrastructure in remote

areas are important areas of *policy* concern.

Low literacy levels and poor uptake of technology are among the *institutional* problems in mountain areas.

Working Group Two: Asia¹

[Tasks One and Two](#)
[Task Three](#)

¹ The participants in this group were: M Young (Chairman); C Devendra (Rapporteur); C Chantalakhana; C de Haan; M Jabbar; T Komiyama; S Mack; V Ostergaard; M Mohammed-Saleem

Tasks One and Two

Discussion focused attention on the three major agroecological zones, the *humid and subhumid*, the *arid and semiarid* and the *highlands* zones.

Analysis of trends over the recent past and expectations and identification of opportunities for the future could only be covered superficially. The working group did observe, however, that:

- investment in livestock research and development has been falling in Southeast Asia but the rate of decline is expected to slow down in the future;
- human populations are expected to rise rapidly but this will be accompanied by an increase in average income;
- the rapid rate of increase in cropped area is not expected to continue and that early in the 21st century a change to tree crops expansion in the areas of oil palm, rubber and citrus fruits may even reduce the total crop area; and
- increases in livestock numbers will mainly be in pigs and poultry.

Task Three

The emphasis was on opportunities, constraints affecting them and supporting research and development strategies in order to define broad priority research areas and move from there to development issues. Six major research areas were identified (Table 1) within which specific issues were further indicated. Research areas are ranked in order of importance and within each the magnitude of a particular constraint is further identified with a score assigned for the amount of research needed.

Development priorities

Development must be a partner in research. If both research and development efforts focus on defined problems the outcome for farmers and herders on low incomes is likely to be a significant increase in productivity. The focus, consistent with recommendations elsewhere, is on *lowland rainfed* systems. The core development themes could be:

- community development supported by research on alternative network options and initiatives to encourage local groups to improve the productivity of the resources they manage;

- applied research and technology transfer with a view to substantially improving linkages between research and extension, increasing the efficiency of extension and using this process to adapt strategic research findings to local conditions;
- price policy so that the probability of adoption of general recommendations arising from pure policy research is high.

Table 1 Research areas and priority ratings in Asia

Research area	Zone ^{a)}		
	Humid/subhumid	Arid/semiarid	Highlands
Feeds			
Production	+	+++	+++
Conservation	++	-	++
Utilization	+++	++	++
Systems			
Dynamics	+	++	++
Animal movement	-	+++	+++
Watershed management	+	-	++
Environment/Indicators	+	+	+
Orientation/Methodology	++	++	++
Research capacity ^{b)}	+++	+	+
Genetics			
Animals	+	++	+
Plants	+	+	+
Policy			
Domestic, including sequencing	++	+	++
Socio-economics			
Scenarios	++	++	++
Community development	+	+	+
Health policy	+	+	+

Notes:

a) +++ most resources needed; ++ average resources; + least resources

b) the combination of existing capacity and its use for technology transfer in a systems approach

Linkages between research and extension could be further strengthened by setting firm time specific targets. Research partnerships, for example, could aim to develop the means to achieve a five per cent improvement in livestock productivity by 1999 and developers to extend this gain to, say, six other areas by 2005. Field rather than station research might be an important element in the pursuit of such targets.

Implementation strategies

From an Asian livestock perspective it is clear that the efficiency of many research and extension programmes is low. It is consequently recommended that attention be given to the development of indicators of effectiveness so that there will be faster transfer of potential benefits at less cost. It is considered, however, that this is a global problem and would be

more effectively approached as such.

A parallel problem is lack of awareness of emerging research technologies and methodologies among scientists working on core problems. This is particularly so in the suggested focus on the development of systems thinking and integrated systems. It may be useful to invite experts in these disciplines to provide short courses with a view to training people in the emerging techniques so that an understanding of ecosystem processes can be gained.

A third consideration is the need for a forum to bring together research and development specialists that for Asia or by theme would:

- develop draft proposals;
- acts as a coordinating body; and
- evaluate and/or supervise projects where this is appropriate.

In all these developments maximum use should be made of existing bodies and structures.

Working Group Three: South America and the Caribbean¹

[Task One](#)

[Tasks Two and Three](#)

¹ The participants in this group were: L Pearson de Vaccaro (Chairman); A D Irvin (Rapporteur); D DeRosa; P-C Lefèvre; J Maki-Hokkonen; N Ole Nielsen; P Osuji; B Shapiro

Task One

Indicators

Indicators under this task are presented in a uniform way across subregions (Table 1). Those taken into account include indicators relating to: demography; macro and trade policies; consumption; imports; exports; inflation; land availability and use; income indicators; impact of attitude to adoption of new technologies; trends in production systems; product yields and offtake rates; input sales for livestock; importance of livestock products in diets and elasticities of demand; structural adjustment programmes leading to opening of markets; and regional and international trade agreements.

Table 1 Development indicators for Latin America and the Caribbean

Subregion and country	Urbanization			Infant mortality ('000 live birth)	Calories/day (per caput)	Economic growth (GDP %)	Inflation (1980-1990 %)
	Land area ('000 km ²)	% total population (1990)	Growth rate (1980-1990)				
Central America and Caribbean							
Costa Rica	77	47	3.3	16	2808	3.0	23.6
Dominican Republic	49	60	4.0	56	2359	2.1	21.8
Mexico	1958	73	2.9	39	3052	1.0	70.3
Nicaragua	130	60	4.5	55	2265	-2.2	432.3
South America							
Argentina	2767	86	1.8	29	3113	-0.4	395.2
Brazil	8512	75	3.4	57	2751	2.4	284.3
Chile	757	86	2.3	17	2581	3.2	20.5
Columbia	1139	70	2.9	37	2598	3.7	24.8
Peru	1285	70	3.1	69	2186	-0.3	233.9
Venezuela	912	84	2.8	34	2582	1.0	19.3
Region	20397	71	3.0	48	2721	1.6	192.1

Resource base

The region has a human population of about 450 million people of which more than 50 per

cent live in urban areas. Cultivated land is equivalent to 0.43 ha/caput compared to a figure of 0.24 ha for the developing world as a whole. Grazing land is equivalent to 1.27 ha/caput against 0.49 ha. Crop output is US \$ 144.8 per caput in Latin America and the Caribbean which is considerably higher than the US \$ 92.9 for the whole of the developing world. At US \$ 78.1 per caput livestock output is more than two and a half times more than the US \$ 31.9 of low income countries as a whole.

Production

Milk production increased by 23 per cent from 1985 to 1990, rising from 19.9 million tonnes to 24.6 million tonnes and is now equivalent to 0.23 litres per caput per day. Increased output came, however, from a greater number of animals and not from higher production per animal. Milk production is lower than demand, the deficit being made up by imports valued at US \$ 1000 million in 1990.

Meat production, mainly beef, in 1990 was 6.3 million tonnes, equivalent to 13.9 per cent of world beef production. As for milk, production increases are mainly from horizontal expansion and not from animal productivity increases. Horizontal expansion of the meat industry means that the cattle population is gradually being displaced to more marginal land. Meat production exceeds local demand and allows considerable exports but regional consumption per caput shows a downward trend. There has been a slight increase in milk consumption.

Conclusions

There is extremely rapid urbanization of the human population. The rural population declined from 50-60 per cent in various countries of the region in 1960 to 10-40 per cent in 1990.

Large ruminant production is growing slowly but consistently. Productivity indicators per head, however, are stagnant and increased production is resulting from larger numbers of animals. Milk production has not kept pace with demand and urban growth. Relatively low land prices allow production systems to remain extensive in nature and there is little pressure to intensify in many areas.

Price policies have focused on urban consumers and this has been assisted by subsidized prices of imports from the European Union. Prices paid to consumers have remained low.

Privatization is proceeding apace.

Tasks Two and Three

Priorities must be set for lowland humid and subhumid (forests, grazing (llanos), cerados) and semiarid (northeast Brazil, West Coast) and highland (including hillsides and altiplano) agroecozones.

The **goal** is the sustainable improvement of the welfare of people and the environment, which can be described as ecosystem health. Purposes, outputs and activities were identified to fulfil this goal (Table 1).

Table 1 Purposes, outputs and goals needed to achieve the goal of ecosystem health

Purpose	Outputs	Activities
Optimize contribution of livestock to national economy and welfare	Improved farm income and rural development	Conduct systems evolution studies
		Strengthen technology transfer
		Evaluate appropriateness of technology
		Evaluate macro-micro policy linkages

	Improved health and welfare of rural and urban poor	Assess determinants of intra-household welfare
		Assess determinants of health and nutrition
		Evaluate macro-micro policy linkages
	Improved policy	Interpret regional policy and trade
		Determine impact of international trade policy
		Conduct livestock sector policy analysis
		Conduct macro policy analysis
		Improve public information and awareness
		Strengthen decision support systems to inform policy
		Improve rural services and security
		Improve land use and resource conservation policies
	Improved stock markets	Improve efficiency of markets
Improved conditions for research on crop/livestock systems	Support appropriate research facilities at strategic locations	
	Ensure adequate funding for infrastructure, personnel and research and support costs	
Increase livestock productivity	Optimized feeding strategies	Increase efficiency of use of fibrous foods
		Improve understanding of agronomy and physiology of appropriate plant species
		Improve feed quality of plants through genetic selection
		Improve technology of forage conservation
		Extend use of fodder trees
		Exploit agro-industrial by-products for feeds
	Reduced animal health constraints	Farm scale
		Conduct epidemiological on-farm assessment of determinants of health and productivity ("sentinel farms")
		Community scale
		Provide low input animal health management services
		Encourage privatization of veterinary services
		Regional or national scale
		Assure effectiveness of laboratory services to support veterinary and animal science services
		Develop policies to protect indigenous stock from foreign or named diseases and chemical residues and thereby provide health standards to permit export
International scale		
Develop means to control high priority diseases where indigenous resources are inadequate and advanced research institutes are not involved		
Develop GIS methodology to detect and monitor environmental indicators relevant to disease, feed resources and natural resource conservation		
Selected, improved and appropriate species/breeds	Evaluate genotypes (biologic and economic) for use in various production systems	
	Connect genetic improvement programmes to	

		reproduction (e.g. AI) services
		Select and improve predominant populations
		Formulate national policies on genetic improvement for sustainable production systems
		Define genotypes which justify conservation
	Improved understanding of role of livestock in farming systems	Develop/assess farming systems database within agro-ecological zones
		Define role of livestock in farming systems and develop models to monitor and predict effects of change
		Define productive exchange in livestock/crop systems
		Define social and cultural values of livestock
		Establish economic and social (including gender) activities
		Identify problems and priorities perceived by farmers
	Better training and education programmes	Insert modern concepts of sustainable tropical animal science and problem based learning into university curricula
		Improve selectivity of information and transcontinental exchange
		Connect extension services to national research institutions
		Promote production and distribution of texts suitable for all users (universities to farmers)
		Increase exposure of teachers at all levels to practical problems and modern research findings
		Provide comprehensive continuing education to national scientists on animal production systems at farm and community scales
		Develop case studies for educational purposes
		Support graduate and post doctoral training with special emphasis on on-farm research
	Better product quality and improved processing	Improve quality control for markets
		Improve on-farm quality control
		Improve food safety
Maintain/enhance natural resources and biodiversity in livestock systems	Maintained/enhanced soil fertility	Enhance soil fertility by increased use of organic fertilizers
		Improve grazing systems in plantation agriculture
		Extend use of appropriate fodder trees and plants in crop/livestock systems
	Stabilized hillsides and reduced erosion	Identify appropriate fodder trees and plants to stabilize slopes
	Reduced deforestation and slash/burn practices	Promote sustainable use of land through legume based mixed farming practices

Final Plenary Session

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Discussion on Working Group presentations

Sub-Saharan Africa and West Asia and North Africa

Sub-Saharan Africa

There seems to be some confusion between "highlands" "high population density countries" such as Burundi which are also in the highlands. Population densities are high throughout the East African highlands. Some other way of distinguishing between highland countries such as Burundi and Ethiopia that may differ in agricultural potential as a result of differences in relative population densities should be found. Perhaps this could be done on the basis of agricultural systems (Thomas).

It was indicated that efforts should be concentrated in high potential areas but that not much can be done for low potential areas (Lefèvre). It was said that policy research is very important in the low potential area but that the success of technical research cannot be guaranteed (Peters).

The group stressed very important issues concerning education and research-extension linkages but "assessment of social needs" should be added to help development of analytical tools for policy decisions and for help in improving organizational efficiency (Ostergaard).

Studies on heat tolerance and adaptability have been indicated in TAC documents as a research need. Perhaps genotype-environment interaction studies would cover the needs if genotypes are evaluated biologically and economically (Vaccaro). Cost-benefit studies on genetic resource conservation and the development of methodologies to define which genotypes justify conservation are needed (Peters).

West Asia and North Africa

It was said that the reasons for farmers not adopting legumes were not known. In the late 1980s an ICARDA conference on ley farming in the Mediterranean basin included WANA. Several papers dealt with the biological, socioeconomic and policy reasons for lack of uptake of the technology (Thomas).

Relying on industry to develop vaccines for low income farmers in the developing countries may be ill-advised. The profitability of such products is often too low to justify investment in vaccine development by commercial interests (Ole-Nielsen).

Asia

Similarities between the priorities drawn up by the working group for Asia in this Roundtable and those drawn up by the Asian group at the ILRI Global Agenda for Livestock Research

Consultation in Nairobi in January 1995 need to be identified (Thomas). There is a great deal of similarity: the Nairobi meeting ended at the identification of research needs but this Roundtable has gone further and examined development issues, especially how best to involve farmers in the research process and to extend research results to the farm (Devendra).

The impression given by the list of tasks for the future is that there is not much need for technology research on health issues in Asia (Lahlou-Kassi). This was the view of the group (Devendra).

The consultation process used by ILRI/FAO is an approach where people identified as knowledgeable in a mandate area are asked to help prioritize research needs. In the absence of other objective criteria this is better than it being done in-house (Osuji).

Mixed crop-livestock systems involving ruminants and non-ruminants were identified as very important and that research should be done on non-ruminants. I presume that what was being emphasized is that if non-ruminants are present in a system they should of necessity be studied as part of it, rather than change ILRI's emphasis on ruminants (Osuji). The presumption is correct (Devendra).

Latin America and the Caribbean

The focus on policy issues is appropriate. There is a need to know what will be required in terms of resources and organization in order to carry out the policy work and which key constraints must be overcome to achieve the objectives (Ehui). There is a great amount of waste now on work that is not all that relevant and resources should be redirected to more important work (Vaccaro).

The approach used by the group is interesting and thought provoking. If the on-farm and decentralized approach to research that is advocated is to succeed it needs to be properly funded and staff working outside headquarters stations will need to be given equal conditions of service, opportunities for promotion, adequate mobility, and effective equipment to do the excellent work that is required. The cost implications need to be studied in determining approaches and modalities for research (Oram).

General comments

Farming systems research has proved very costly and has not been very successful in sub-Saharan Africa. The reasons for this are low budgets and a paucity of systems information. Information systems to provide a basis for decision making are required (Peters).

The frustrations expressed about the apparent failure of on-farm systems research in Africa, attributed to too much reliance on costly diagnostic surveys, are understandable. The time devoted to this work led to criticism of on-farm research that was probably premature. The main problem was that real objectives and problem definitions were not sharp enough and lead to the collection of costly and unnecessary data. These were either not analyzed or, if they were, contributed little to the removal of the ill-defined constraints (Osuji).

One of the basic reasons for research failure in the past was that there was no genuine needs assessment of rural farmers. As these farmers do not "own" the problem to be solved by research activities they do not own the solution which could affect their future. This applies to systems analysis as well as to applied research. These are complementary and both are needed (Nana-Sinkam).

On-farm research might be managed effectively through village agroecosystems. "Failure" of farming systems research might have occurred in part because insufficient attention was paid to an ecosystem approach and the hierarchy of nested ecosystems that comprise the animal

production system. A system cannot be studied in isolation, especially if achieving sustainability is one of the objectives. A recent publication presents a lucid and well argued case for assigning "the community of the village agroecosystems" as a relevant and embracing social and spatial unit of analysis to operationalize sustainability. It is also worth noting that during the last 10 years there has been rapid development of epidemiological methods to conduct on-farm or field research to identify determinants of health and productivity (Ole Nielsen).

Systems analysis/systems thinking, for example livestock systems research with farmer participation, is not only appropriate but also an absolute necessity if progress is to be made in development work. It also benefits the various disciplines involved and enriches the research output (Ostergaard).

Support for helping people in low income countries through livestock development needs some institutional structure based on sustained allocation of funds and manpower. Involving farmers in the process is important but the main objective in promoting livestock development is to gain public support for increased funding for research and development. A mechanism must be found that takes into account the concerns of the public, interest groups and policy makers in developed countries. If this is to be accomplished in an effective manner a secretariat of representatives from the CG system, FAO, the World Bank, other international development agencies, regional institutions such as SACCAR and CILSS and NARS is needed. This secretariat could, *inter alia*, do impact analyses and distil research results to make them palatable to the public. A global forum, a secretariat, a policy network and a "2020 vision for livestock" are complementary activities (Shapiro).

In attempts to publicize the role of livestock and promote policy research it must be remembered that this costs money. If the idea of publicizing the importance and role of livestock and trying to dispel misconceptions about their influence on the environment is to succeed it will have to be well crafted. Funding may have to be a consortium effort but setting up a policy research group might fit within the systemwide livestock initiative and be funded through it. With regard to comments on the public attention attracted by IFPRI's 2020 initiative on micronutrients it should be noted that this was a user friendly and novel approach to improving human nutrition and drawing attention to a hitherto unrecognized problem. IFPRI has not much experience of livestock issues but is now trying to correct this. It is hoped to establish a working relation with ILRI and FAO to develop a 2020 position paper on research needs for livestock policy in relation to future demand and supply for animal products (Oram).

Policy is highlighted as important but policy is swayed by politics, external funding, resource allocation, interest lobbies and many other factors. Livestock make a major yet still undervalued contribution to development. Many answers have come out of this meeting and many constraints and opportunities have been identified. We must now exploit the results and build on the synergy (Mack).

Peroration

The main point arising from the roundtable is that the welfare of small farmers and herders - and not of livestock- is the goal. Livestock research and development must turn that goal into reality. The case for livestock must therefore be presented to show that improved production will have no adverse impact on opportunities to feed future people, maintain environmental quality and conserve genetic resources.

The new vision places livestock in a production and an ecological system. There are immense opportunities to improve the welfare of producers and consumers by further integration of crops and livestock into truly mixed systems. This new system thinking, however, presents a challenge. Experts in systems analysis and modelling need to be brought into livestock

research fore. A critical factor for further progress will be a clear articulation of the role of livestock in advancing human development.

Understanding of the consequences of continuing with the *status quo* versus the pursuit of visionary but realistic alternatives must be developed as part of the process. A capacity to create development scenarios and policy alternatives has been identified as a need, requiring the blending of Global Information Systems and modelling with policy analysis techniques. The resultant framework should show where livestock can make a difference. It could form the basis of a set of research and policy decision support systems for use by international, national and local organizations.

Progress in the development of realistic scenarios needs to be supported by research on indicators of performance - ecosystem health - so that the models can be kept simple and persuasive. Research on indicators will also be useful in clarifying the relations between livestock and the world's environment.

One of the greatest openings for progress lies in the identification of opportunities to improve livestock policy and the institutional arrangements that influence livestock management and investment strategies. Land tenure arrangements, for example, can give investment security and facilitate joint management of resources. New price and regional trade policies would do much to improve overall welfare and reduce land degradation. As some of these reforms would bring about significant structural adjustment it is important that work in this area identifies the most effective order or sequence in which to implement change. Simple and generalized recommendations that fail to clarify the impact of change, for example, on a hillside farming community are insufficient and only serve to discredit livestock research.

Past research agendas have failed to involve local farmers. Isolated behind field station gates much research has seemed, and on examination has proved, to be irrelevant. Research projects that focus on problems that are not relevant to farmers' needs risk failure. The alternative is a research environment that creates a seamless link between resource use, people, development, extension and research. Development projects, for example, can be modified to provide the adaptive platforms necessary for effective research. Animal breeding trials and forage utilization trials can be conducted on-farm.

The search for new research mechanisms suggests a parallel need for research on ways to encourage local communities to solve their own problems, to form their own organizations and, even, to commission research. Overall the vision is one that is output and product focused with people at the centre. Problem recognition, firm product targets, clear hypotheses, system thinking, policy relevance and small farmer welfare provide focus for that vision.

Recommendations

The livestock roundtable concluded its meeting with optimism and purpose. In particular, it felt that the new vision of livestock research and development working in partnership must result in the development of an action plan. It resolved unanimously:

- that senior representatives from FAO and ILRI meet before May 1995 to form a **Livestock Research and Development Forum** with a charter to
 - coordinate livestock related research and development across the developing world,
 - identify opportunities to create synergies between development and research by, for example, targeting work in the same region and designing projects so that they can be used for complementary

research and development purposes,

- ensure that research conclusions are incorporated into development proposals as soon as possible,
 - act as a clearing house for information about livestock development and research proposals,
 - facilitate the refinement of draft project plans by means of appropriately constructed working groups,
 - endorse integrated development/research plans for submission to donors,
 - promote livestock's image in development and the potential for research on livestock production and resource conservation to enhance their positive contribution to sustainable development, and
 - identify opportunities for developing innovative livestock communication strategies.
- that FAO/ILRI/IFPRI develop a proposal for a **Livestock Policy Research Network** for submission to the livestock planning group responsible for implementing the CGIAR's new Systemwide Livestock Initiative.
 - that ILRI, in association with FAO, take a lead role in developing the image of livestock, livestock research, and livestock development.
 - that ILRI ensure that the new CGIAR communication strategy give prominence to livestock research.

It is anticipated that the executive of the Livestock Research and Development Forum would comprise a small group of senior FAO and ILRI representatives responsible for the general direction of livestock research and development. The opportunity to expand this executive to include representatives from other agencies, NARS and farmer organizations should be considered. The Executive would be aided by a Secretariat comprising senior representatives of FAO and ILRI. One or two resource persons could be appointed to the Executive and/or the Secretariat as appropriate. Opportunities to allow open membership of the forum and hold periodic meetings should be considered carefully. It is envisaged that the forum's Executive would meet at least once a year and, through its Secretariat, convene regularly by e-mail.

Annexes

Annex I: A global agenda for livestock research: an ILRI consultation

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Introduction

The International Livestock Research Institute held a Consultation on "**A global agenda for livestock research**" in Nairobi, Kenya from 18-20 January 1995.

ILRI faces major challenges in a changing CGIAR framework. It needs to generate a coherent research programme from the two disparate ones of the former International Livestock Centre for Africa and the International Laboratory for Research on Animal Diseases. It must develop, concurrently, a global agenda for research and put in place a systemwide livestock research programme in collaboration with multiple partners. The timetable for establishing these programmes is constrained by structural adjustments and programme timing in the CGIAR itself.

The Consultation was part of a continuing process within which ILRI will need to choose the most appropriate research areas for its involvement. In doing this it will need to take account of its own comparative advantage, its limited resources and the requirement for developing research collaboration with future regional and national partners.

Objectives

The objectives of the Consultation were to:

- identify priority needs for improved livestock productivity and the development and establishment of sustainable production systems in the developing regions;
- identify cross-regional priorities, major constraints, and researchable areas and issues in livestock production most likely to bring direct benefits and impacts; and
- assist to identify participants and planning for future regional research workshops.

Participation

The Consultation was attended by 30 persons from 25 countries from all the developing regions (Asia, Latin America and the Caribbean, sub-Saharan Africa and West Asia and North

Africa) of interest to the CGIAR.

Participants were invited in their individual capacities but represented experience from many national programmes and 11 international agricultural research centres and donor communities

Programme

The programme was divided into four sessions.

Session I

Following welcome remarks and an opening address two reports were presented:

- "Livestock and environment initiative" (H Blackburn, USA)
- "Ecoregional analysis of livestock production systems" (A W Qureshi, FAO)

These two reports were then discussed and this was followed by an introduction to the separate regional group meetings.

Session II

This session comprised presentation of regional papers and the discussions held on them.

- South Asia (K Singh) and Southeast and East Asia (C Devendra)
- Latin America and the Caribbean (M E Ruiz)
- Sub-Saharan Africa (W Masiga)
- West Asia and North Africa (A Sidahmed)

Session III

Substantive discussion of major themes and research dimensions by the four separate regions were the subject of this session.

Session IV

The final plenary session comprised presentation of individual group reports, a final discussion, arrival at a consensus and drafting of conclusions.

Summary of regional working group reports

Asia

There is a need for separate research foci on two priority agroecological zones: the humid and subhumid and the arid and semiarid zones. These broadly correspond to Southeast Asia and Indochina for the first and South Asia for the second. Parts of China and Mongolia fit one or other zone. Six areas for future research were identified (Table 1).

Latin America and the Caribbean

Particular attention was given to the tropical subhumid and humid zone (including hillsides, lowlands and forest margins), the High Andes and the Caribbean and southern part of the continent. A total of 12 researchable areas was identified with five being considered key themes (Table 1).

Sub-Saharan Africa

This developing area was considered to comprise the arid, semiarid, subhumid and humid zones. Seven major themes were identified as priorities for research (Table 1) although priority was considered to vary with the severity of the various constraints within each of the zones.

West Asia and North Africa

The region includes extensive range production systems and mixed systems with some irrigation. Major constraints are lack of land and water and very high population growth rates. The possible extension of the region to include the steppes of Central Asia and part of Mongolia was recognized. Six priority areas for research (Table 1) were identified.

Table 1 Priority research areas for the developing regions

Developing region and research priorities			
Asia	Latin America and the Caribbean	Sub-Saharan Africa	West Asia and North Africa
feed resources	natural resource issues	feed production and use	production systems
systems-oriented research	feed resources	animal health	natural resource management
epidemiology	animal genetic resources	systems analysis	feed resources and nutrition
institutional and policy related issues	animal health	natural resource management	animal genetic resources
animal genetic resources	socio-economics	conservation and biodiversity (animal and forage resources)	animal health
better application of technology and use of research results		animal genetics	policy, socio-economic and institutional research
		policy and socio-economic issues	

Summary of common research themes

Common research themes arising from the separate group reports and discussed in plenary session were:

- feed resources
 - production
 - use;
- production systems
 - systems analysis
 - integrative management;
- biodiversity
 - characterize, conserve and improve;
- animal health

- expanded focus for improved epidemiological and impact evaluation on productivity and integrated management technologies;
- policy; and
- strengthening of NARS.

The regional papers and group discussions underlined the importance of establishing priority lists of research objectives against an ecoregional framework. The lists may thus represent common needs that qualify for international research effort and delivery of technology. Individual elements may, however, be pursued within one ecoregion through collaboration with regional partners.

Annex II: WAAP/FAO International symposium on the supply of livestock products to rapidly expanding urban populations

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Introduction

The World Association for Animal Production and the Food and Agriculture Organization of the United Nations will host an International Symposium on "**The supply of livestock products to rapidly expanding urban populations**" in Seoul, Korea from 16-20 May 1995. This symposium is considered a logical follow up to the "**Roundtable on livestock development strategies for low income countries**" sponsored by FAO and ILRI in Addis Ababa, Ethiopia from 27 February-2 March 1995. The Seoul Symposium will concentrate primarily on commodity supply issues faced by the product chain from the farm to the consumer and in particular those issues having a policy or technology dimension.

As per caput incomes in developing countries rise food consumption patterns change in favour of absolute or relative increases in foods of animal origin. Life styles are also likely to change towards a more "western" concept with more consumption of animal products and vegetables than of cereals.

Urban-rural migration is taking place in many developing countries concurrently with economic progress. Cities with more than one million people will be home to more than 60 per cent of the world's population by the year 2025. An individual farmer will need to produce more food to supply the needs of his urban counterparts. Urban food security cannot be assured, however, by subsistence farming or by simply raising farm productivity. New, more complex, and integrated systems of preservation, processing, marketing and distribution will be needed than those that have so far served the needs of a predominantly rural world. Market services in particular will be critical to rural and urban food security and, when supported by appropriate policies, will result in many social and economic benefits.

It is thus timely to organize an international symposium on the production, consumption and supply system of livestock products. The Seoul symposium will focus on linkages in the farm to producer chain which will have a major effect on the evolution of livestock production systems. Its outcome will also assist developing countries to design appropriate strategies to meet the challenge of constructing better links between rural producers and urban consumers.

Objectives

The objectives of the Symposium are to:

- review trends in production and consumption patterns of animal products, with special emphasis on developing countries;
- share experiences in production, consumption and commodity supply issues; and
- draw up policy recommendations for the improvement of regional commodity supply systems and suggest future strategies to meet the demands for livestock products by the rapidly expanding urban populations of the world's developing countries.

Participation

Some 100 participants are expected to take part in the symposium. About 50 of these will be local scientists, administrators and technical staff. A further 40 will be invited speakers and senior officers of WAAP and regional organizations. Selected livestock advisers from developing countries and some leading international organizations and institutions will complete the list of participants.

Programme

The programme will be in nine parts.

A. Opening ceremony

Following opening remarks, a welcome address and a congratulatory address by Korean and other dignitaries two background papers will be presented:

- A quantitative study of world livestock production systems (A W Qureshi, FAO)
- Summary of FAO/ILRI Roundtable on livestock development strategies for low income countries (R Trevor Wilson, UK)

B. Keynote papers

- Global issues in meeting urban demands for livestock products (J Phelan, FAO)
- The role of international institutes in the supply of animal products to urban populations: a case for ILRI (H Fitzhugh, ILRI)
- Present and future of Korean animal agriculture (J I Chun, National Animal Research Institute)
- World production and consumption of animal products: common features and future developments (In K Han, WAAP)

C. Conceptual framework

A series of papers will review commodity supply systems for major animal products and the importance of technology in the delivery of products to urban populations.

- The evolution of livestock production systems in developing countries: an economic analysis (V Ostergaard, Foulum Research Center, Denmark)
- The commodity supply systems for milk: common features and trends (H Schelhaas, Produkschap Voor Zuivel, The Netherlands)
- The commodity supply systems for red meats, poultry and eggs: common features and trends (R Ahmed, IFPRI)
- The role of technology and hygiene in supplying livestock products to urban populations (G Heinz and J C Lambert, FAO)

D. Case studies - I

Production and supply systems suitable for a given area are influenced by social, geographical and climatic factors. Some typical examples will be presented in two sets of case studies.

- China's rapidly evolving livestock commodity systems: challenges and implications for international markets (Shag Bu Liu, Beijing Agricultural University)
- Privatization of livestock development approaches in the Punjab: experiences of the Patocki livestock production project (G Herrenthey, GTZ, Germany)
- Periurban dairy production in sub-Saharan Africa: a systems-wide constraints analysis (S Ehui, ILRI)
- Supplying meat and milk to selected cities in Pakistan and Vietnam (J Phelan, FAO)
- Adaptation of red meat and milk commodity systems to an adverse macro scenario: the West African case (J M Centres, GRET, France)

E. Case studies - II

- Livestock retailing in a setting with an uneven urban income distribution: the case of Latin America's large cities (B Quinones, Colombia)
- The development of animal production systems to meet consumer demand in Japan, Korea and Taiwan (T Morichi and T Miyashige, NIAI, Japan)
- Dairy development in Thailand (C Chantalakhana, Thailand)
- Strategies for the delivery of inputs and services to small scale livestock producers (C de Haan, World Bank)
- Strategies for delivery systems to small scale livestock producers and linking rural producers of milk and meat with urban markets (P N Bhat, India)

F. Recommendations

Recommendations will be made for national and international strategies for improving supply systems to rapidly expanding urban populations.

1. Working groups

Working groups will be constituted to look at:

- national planning and policy analysis and implementation framework; and
- international interventions - development of a prioritized agenda for commodity supply systems for animal products

2. Plenary session

Working group findings will be presented and action plans, conclusions and recommendations drawn up.

G. Poster presentations

Contributed posters by young scientists and graduate students will be a highlight of the symposium and will cover four areas:

- nutritional values of livestock products;
- production technologies for better quality animal products;
- relations between supply and demand for livestock products; and
- new technologies in processing of foods of animal origin

H. Technical tour

A technical tour of one and a half days' duration will allow participants to gain insights of Korean livestock production systems and of storage and processing facilities for milk and meat and concentrate feed production.

I. Closing ceremony

Closing remarks, a closing address, a summary of the symposium and any announcements will bring the meeting to an end.

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