ANIMAL PRODUCTION SYSTEMS RESEARCH IN DEVELOPING COUNTRIES: OVERVIEW AND PERSPECTIVES

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Abstract

Livestock in developing countries is an important activity in the use of natural resources. Perspectives on livestock's role differ between developed and developing countries due to differences in needs and aspirations of their populations and the production systems employed. An analysis of supply and demand of livestock products in developing countries, trends in population growth and economic growth as well as urbanization indicate a substantial potential for the development of the livestock sector. In order to achieve it, new development concerns, including the search for equity and sustainability, have to guide future research on the management of natural resources.
Within this context, holistic and participatory research activities need to be expanded to ensure appropriate analysis of selected situations throughout the developing world, incorporating socio-economic, political and bio-physical perspectives. Systems research provides the tools to find solutions for complex problems. Previous experiences in farming systems are a valuable starting point to be used in dealing with new challenges and opportunities. The research focus needs to be expanded to link efforts at the different hierarchical levels (ecoregions, locations, farms, animal systems), and to link the animal enterprise to other farm components, as well as to other activities beyond the farm gate (marketing, processing and utilization). To achieve large scale impact and have an attractive social return systems research efforts will have to enhance the interphase between the generation of knowledge and policy formulation.

Key words: farming systems research, developing countries, animal agriculture, sustainability.

I. INTRODUCTION

The role of animals in future societies is being questioned both in the developed North and the developing South. In developed countries policies have led to highly intensive production systems under attack for the negative environmental impacts, the high cost to the taxpayer, the animal rights being infringed and the quality of the products being placed on the markets (Durning and Brough, 1991).

In developing countries livestock research and development is being questioned from somewhat different angles:

- Ecologists are concerned about the impact of livestock development on desertification and rainforest clearing.

- Environmentalists are worried about its contribution to methane production and global warming (Byers, 1990).

- Nutritionists and economists argue that the poor should have more access to energy and plant protein and that animals are competing with humans for scarce resources (water, land, cereals).

- Research managers are worrying about a perceived lower social return of livestock research vis a vis crop research.

On the other hand livestock fulfill a series of important roles in tropical farming systems:

- Utilization of feed resources not directly used by humans, such as rangelands and crop byproducts.

- Supply of animal traction services and manure, which are key inputs to crop production.

- Enhancement of soil fertility management through the inclusion of forage legumes in the farm system given their capability to fix atmospheric nitrogen.

- Provision of liquidity to farmers with difficult access to banking systems either through the continuous income stream generated by milk or egg production or through the possibility of rapidly selling animal assets in case of need of cash.

These roles have been extensively documented across the developing world (Ruthenberg, 1980; Beerling, 1991; WINROCK, 1992). This paper does not pretend to offer answers to all of the above questions but rather to review the trends in animal agriculture in LDCs, to provide an overview of the past experience in developing systemic approaches to deal with animal agriculture and to identify emerging issues and concerns as well as methodological developments to

enhance the contribution od science to maximize the contribution of animal agriculture to sustainable and equitable development in the Third World.

II. THE STATUS OF ANIMAL PRODUCTION IN LDCs

1) Demand

Demand for animal products in developing countries is determined by two main factors: growth of population and increases in consumption per capita. Table 1 shows population of various regions of the world, recent growth rates and forecasts. In spite of declining growth rates, total population will still grow substantially in most LDCs.

Despite important regional differences, consumers around the globe tend to enjoy the consumption of animal products: milk and dairy products, red and white meats, fish, eggs. Substantial differences can be observed between regions both in terms of total per caput protein consumption as well as in the share of animal protein thereof, with Africa and the Far East well below the global and LDC mean values (Table 2). The overall inclination to increase consumption of animal protein as incomes increase is shown by Fig. 1. Both present consumption patterns and preferences observed lead to the conclusion that LDC societies will demand increasing supplies of animal products, particularly if incomes grow as expected.

Beyond the direct implication for the need to cater for this growing demand as incomes rise, a further important aspect is the fact that opportunities for farmers to achieve an income by allocating resources to animal production increase in the course of the development process.

2) Supply

Livestock constitute an important production resource for developing countries (Table 3). For Sub-Saharan Africa ILCA has estimated that livestock represents about one fourth of the agricultural domestic product. This figure only reflects the value of marketable outputs but excludes the value of animal traction, manure, etc. Including their value would increase the contribution of livestock to agricultural domestic product to about 35 % (Winrock, 1992).

A number of livestock species are found mainly in LDCs, a fact determining the limited stock of developed country research upon which to build. Substantial gaps in animal productivity exist between developed and developing countries (Table 4). Growth of stock numbers has in general contributed more to total output growth than yield increases, a fact explaining the expansion of

ruminant production into increasingly fragile marginal lands. Both environmental and economic reasons are putting a ceiling on this form of production increase, thus implying that future output growth will increasingly have to be achieved through intensification of production on land resources already being utilized.

Among the developing regions, the Far Eastern production of both meats and milk has grown fastest in the recent past, while Africa presents the poorest performance (Table 5). This clearly underpins the close links between economic growth and growth potential for animal production (Mellor, 1989). Two different patterns of production can be identified: most LDCs tend to produce meats based on ruminants utilizing feed resources not directly utilizable by humans such as rangeland and crop byproducts. On the other hand countries with scarce land resources, important urban concentrations and rapidly growing demand for animal products tend to produce monogastrics based on grain rations which are frequently imported from developed countries.

3) Trade and prices

Trade patterns in animal products are dominated by the trend of developed countries being the major producers and exporters with LDCs being generally net importers. This picture is determined by the fact that most of these products are produced at both temperate and tropical regions and that developed countries have implemented policies supporting domestic production. This has induced the production of large surpluses which are disposed off by subsidizing their export to LDCs. Milk trade is a particularly extreme case: all developing regions are net importers of dried and condensed milk as well as cheese. Europe is by far the largest net exporting region for all dairy products followed by Oceania and North America. The latter region is a net importer of cheese (Figure 2). Beef trade presents a similar pattern: among the developing regions the Near East is the main net importing region while Latin America is a large net exporter. Among developed regions Europe and Oceania are net exporters, other developed economies (mainly Japan) and North America being net importers. Sheepmeat is internationally traded mainly between Oceania (net exporter) and the Near East (importer). Net trade in pork and poultry is relatively unimportant.

The outlook for these commodities is highly uncertain given the present stage of GATT Uruguay Round negotiations and the potential for reductions in subsidies to feedgrain and animal protein production in developed countries. The latest World Bank forecasts seem to be rather cautious about the potential for price increases for grain, oilseeds and livestock (Figure 3). In this context it is interesting to note the increase forecast for tropical timber. This might increase the attractiveness of agroforestry alternatives including appropriate tree species.

III. SYSTEMS RESEARCH

Systems research is an approach utilized traditionally in physics and biological sciences to understand complex problems and the interactions among components, such as the one between organs and biological systems. The use of systems research in agriculture in developing countries started in the late sixties when interest in the problems of the small farm sector started to grow. At that time, it was realized that results generated by disciplinary work at research stations had limited application under small farm conditions. Thus, it was proposed that an alternative approach was needed to understand better the constraints to small farm development, including farmers' expectations and needs. Appropriate technologies had to be generated *in situ* under farmers' conditions. That approach called for interdisciplinary work, and a holistic view, including biological and socio-economic perspectives (Figure 4).

The approach was used to study cropping systems, starting in the early seventies (Norman, 1976), animal production systems in the mid seventies (Li Pun and Zandstra, 1982), and mixed systems (crop/animals, trees/animals, crop/animal/trees), in the mid eighties. Experiences started in Asia and Latin America, and the approach was also used in some places in Africa. Many national, international and donor organizations were involved throughout the developing world. As experiences grew, more careful attention was given to socio-economic aspects, including gender analysis and household activities.

Experiences have been subjected to several reviews (Shanner *et al*, 1982; Simmonds, 1985; Li Pun *et al*, 1991). Therefore, it is not the purpose of the present paper to go into a detailed description. Furthermore, they will be covered in other presentations that are included in the present symposium. Consequently, emphasis of this presentation is on main benefits and constraints of agricultural systems research projects including animal components.

1. Benefits.

a) A better understanding of the complexities of these systems has been obtained in a variety of ecosystems, and production systems. These complexities have drawn researchers' attention to the fact that limitations of small farmers go well beyond biological constraints and production aspects.

b) The increased understanding of systems has led to the development of component technologies. Results from these efforts have been documented recently in several publications (Li Pun, *et al* $1991_{(a)}$; Li Pun, *et al*, $1991_{(b)}$; Li Pun and Paladines, 1992; Vargas *et al*, 1991; Nitis *et al*, 1991; Riesco, 1990; Romero and Holmann, 1991). They include: introduction of improved grasses and

legumes, better nutrition and feeding, appropriate animal health practices, improved management, better soil management, establishment of revolving seed funds, and others. They have resulted in better animal performance and increased income for participating farmers. Technologies developed have been adopted in many cases. The linkages between changes in the macroeconomic policies and farmers responses have been studied in projects in Guatemala and Costa Rica (Vargas et al, 1991; Romero and Holmann, 1991, respectively).

c) Scientists in many institutions of the developing world have been exposed to interdisciplinary work.

d) Methodologies have been developed for: systems diagnosis, design, on-farm testing and data analysis. They include both hard and soft sciences approaches such as the use of systems modelling and simulation, rapid rural appraisal, techniques to enhance farmer participation, etc.

e) A core group of scientists in developing countries have been trained and have developed hands-on experience in systems research which can be the basis for addressing new challenges with an expanded perspective.

f) Research networks that pursue holistic approaches have been established in the different regions of the world. Important lessons have been derived from the support to networks which have been used to design newer initiatives (Li Pun and Paladines, 1992).International conferences on the subject also have been organized giving exposure and credibility to the subject.

g) Complementarity of systems and disciplinary research is better understood now, avoiding early confrontations between researchers who perceived both approaches as conflicting. Systems research is essential to analyze limitations an identify key entry points to promote changes, identify new research opportunities by providing feedback to researchers based on the performance of technologies or effects of policies under practical situations, as well as to link research with development actions. Disciplinary research is needed to generate the specific information on technological components that can be used to promote change.

2. Limitations and drawbacks:

In the enthusiasm to promote systems research, the approach was sometimes oversold. As a result, large expectations were created, and it was considered by some a "panacea" to solve the problems of small farmers. In fact, now it is recognized that impact of many agricultural research projects that pursued a systems approach has been limited. Causes are varied and include the following:

a) Poorly designed projects. Oversimplification of constraints of small farmers led to the proposal of technologies that worked under similar ecological conditions but that did not work under specific socio-economic conditions. Required duration of projects was also severely underestimated, as often it was proposed that 3-5 years were needed to diagnose problems, design alternatives, and validate them with farmers. Reality has shown that at least 8-12 years were needed to account for: climatic variability, long cycles of animal processes (specially when working with large ruminants), variability of yields (decreasing yields of pastures after establishment when no inputs are regularly added), long life cycles of biological species (ie trees included in alley farming or silvopastoral systems), etc.

b) Diagnosis was often a descriptive exercise of resources, management, and production indices. However, it lacked the analysis of causes and effects, which also required a better understanding of external influences (policies, socio-economic frame and resulting effects: land tenure, credit, marketing, processing, etc). Often the analysis of external factors was done only at the design phase of projects. Therefore, effects of ongoing changes exogenous to the farm were not detected.

c) Client participation in project design, implementation and evaluation was often limited. The projects ignored the contribution of involved farmers and their families in real problem identification, design of alternatives and actual implementation and evaluation. Many projects ignored the role of women in the management of the farm enterprise, which is critical especially in situations when male farmers migrate seasonally, or periodically to search for off-farm income, which is common in many peasant communities (eg. the Andes of Latin America and parts of Southern Africa). In other cases, farmers' objectives in general and specifically the role of animals in the enterprise were not well understood. For example, the multiple role of animals (beef, milk, traction, manure, savings) contrasts with the emphasis of some research projects on only one product. The complexity of mixed systems practiced by small farmers contrasts with the emphasis of changing only one component without considering the interaction with the others.

d) Training of researchers has been discipline oriented. Often researchers in developing countries lacked the exposure to small farm situations and to work in more marginal areas. However, they were given major responsibility in the conduction of research projects under those conditions, without adequate training.

e) In spite of the expressed interest from many institutions in developing countries in pursuing systems research, most continued to be organized along commodity programs, and with a disciplinary orientation. Thus appropriate linkages were not established between systems and commodity researchers.

f) The same lack of linkages occurred between institutions working in research and training and the ones working in extension and development. Therefore, common diagnosis of development problems and joint strategies have seldom been implemented. Few universities have adopted a systems perspective in their training programs.

These constraints have been identified and discussed by different groups of researchers. They have also been raised in international meetings (Li Pun et al, $1991_{(a)}$) and within networks dealing with farming systems. It has been recognized that agricultural systems research as applied to the small farm sector in developing countries is a field in evolution. Therefore, projects designed in the last years have benefitted from experiences developed earlier and avoided pitfalls. Future initiatives that require a holistic perspective can be built upon past experiences, taking into account lessons derived from them.

Lessons learned.

The general characteristics that should be looked for in future projects include the following:

a) Systems approaches: holistic, interdisciplinary and participatory research. Although this is not new, an evolutionary approach should be used based on experiences from previous projects and the participation of key disciplines and other actors that facilitate the development of sustainable systems. Depending on the specific situations, participants could be not only farmers, but merchants, processors, exporters and/or representatives from the local governments who could be approached to discuss problems and articulate possible solutions. Conflict resolution approaches for the management of natural resources could be used for the design of alternatives. System analysis and development should be conducted beyond the farm boundaries as to include off-farm activities which could possibly impact on farm processes.

b) Multiinstitutional projects. It is realized that most national, and international institutions and NGOs do not encompass all the needed range of "hard and soft" sciences needed for holistic research. An alternative is to look for the adequate blend of disciplines and strengths across different organizations.

c) Search for policy-related outputs. Research on technology aspects was often conducted neglecting the understanding of the general socio-economic and environmental framework. On the other hand, socio-economic policies have often been formulated without considering technological knowledge generated at the micro level which indicates what is best for beneficiaries and

the environment. Future efforts should look for means to improve this articulation to achieve impact at the farm and ecoregional levels.

d) Representativity. Given restricted financial resources, support to research should go mostly to cases where experiences could be extrapolated to major ecosystems, or could have regional or global impact.

e) Collaboration between donors. Dilution of resources within a country often occurs as a result of donors' interests in target countries and locations, and developing countries' pressing needs. While this international collaboration is needed, better efficiency in the use of resources could be achieved by more concerted efforts. This is as much a responsibility of developing countries as of developed countries and international organizations.

f) Institutionalizing new issues and approaches. Successful experiences should be used to stimulate their adoption by researchers, development workers and their institutions. Appropriate training of human resources is a key to achieve institutionalization.

g) Networking. Its value is highly recognized. On the other hand, its drawbacks need to be recognized in the support to future networks to avoid overloading the research system and diluting the use of resources. Mechanisms should be supported to stimulate entrepreneurial approaches, participation, sharing of costs, benefits and responsibilities. The use electronic media should be encouraged to achieve more interaction and broader participation, access to information as well as reduction in the costs of meetings.

i) Information systems. Support to information systems for decision-making should continue to be a high priority. Given the increasing role assigned to the private sector in economic development, access to information may play a key role to promote sustainable development.

IV. TOWARDS A RESEARCH AGENDA: ISSUES AND CHALLENGES FOR SYSTEMS RESEARCH.

At a global meeting organized by the International Development Research Centre (IDRC) of Canada and the Latin American Animal Production Systems Network (RISPAL) in 1991, past experiences were reviewed and suggestions were discussed to define a new agenda for livestock R & D in Third World countries. A task force was created to undertake that endeavor. It included representatives from IDRC, Winrock International and INFORUM. A series of activities were undertaken, including a survey of research managers, decision

makers, researchers and development workers from institutions interested in agricultural development. Documents on the subject were also gathered. An international teleconference was organized to discuss those topics. Preliminary results have been incorporated into this paper, including challenges and opportunities for the development of the livestock sector.

The new development concerns discussed in Agenda 21 at the Rio Conference organized by UNCED, indicate more preoccupations for sustainable development, including the need to utilize natural resources more judiciously in order to achieve **economic growth**, **equity** and **sustainability**. The last two objectives are relatively new criteria to consider for future R & D efforts. **Equity** implies equal opportunities, and fair distribution of costs and benefits among different sectors of society (urban and rural, socio-economic strata, family members, ethnic and cultural groups). **Sustainability** implies the preservation and enhancement of the natural resources and the environment to ensure that needs of the future generations are met.

These criteria had to some extent already been incorporated in many farming systems projects, especially in the ones that emphasized more participatory approaches, which included work with peasants, small farmers, women and other family members. The search for low input agricultural systems including appropriate rotation of crops, pastures, and combination of crops, trees, and animals in agrosilvopastoral systems, also reflected the above concerns.

These new dimensions of the development process require even more holistic and multidisciplinary approaches and methods. Depending on relative priority of problems diagnosed, future farming systems research projects will require more efforts to incorporate larger systems beyond the individual farm.

In some cases ecoregional approaches will be appropriate as to study ways to manage natural resources. To do it, relations between the different systems hierarchies (ecoregion, locations, farms, animal production systems) will have to be analyzed and synthesized (Figure 5). In other cases, linkages from production to consumption including the assembling of products, processing, storage, transformation, distribution, and utilization are particularly important to identify opportunities to enhance farmers' incomes and overall welfare (Figure 6).

Within this context, the role of animals could be better defined, considering needs, aspirations and abilities of users of natural resources (farmers) combined with those of society at large.

Based on the potential of the livestock sector in developing countries, as discussed in this document, well focussed research efforts can lead to the achievement of that potential. Knowledge generated can be used also for rural development efforts, a better

understanding of preoccupations of society in developed and developing countries, and finding concrete development alternatives.

Main challenges.

The new agenda for livestock systems research should be guided by some of the major challenges that have been identified:

1. Ecoregional approaches. Livestock production needs to be conceived as an activity within the pursual of more integrative activities such as ecoregional approaches, where systems analyses show that they are important in the use of natural resources and a key entry point to improve a given system. For example, agroforestry systems without livestock activities do not make much sense in many cases if pastures and animals are not included to use the foliage, contribute to nutrient recycling, reduce external inputs and produce useful outputs and cash flow for farmers over time. Modelling of systems will be a key in the pursual of these approaches, as well as the use of Geographic Information Systems (GIS), for characterization of ecoregions, site selection, and monitoring and evaluation of sustainability.

   Examples of specific livestock related challenges within different ecoregions are the following:

   - In Asia, a major challenge will be how to cope with rapidly increasing demands for animal products. Can the present monogastric grain-based production systems be sustainable given both demand and environmental trends? What kind of systems should be developed to ensure appropriate recycling of wastes? In the humid zones where export oriented plantations (rubber, coconut, palm oil) prevail, what is the potential of mixed systems (including small ruminants to utilize the undergrowth and contribute to nutrient cycling), especially considering tendencies to reduce the use of herbicides and inorganic fertilizers?

   - In Africa, given low animal protein consumption and severe population needs, what kind of production systems are needed? Will peri-urban more intensive systems be the alternative to cope with a rapidly growing urban population? In the semi-arid zones, what is the potential of agrosilvopastoral systems, and what kind of policies and technologies should be developed to make them sustainable? What are the possibilities for wildlife farming as to ensure the production of useful products and the preservation of species and the development of the ecotourism industry? What kind of natural resource policies are necessary to combine economic development with social and environmental concerns? What are the potential implications of improved

trypanosomiasis control and population needs on forests clearing in the humid zones?

- In Latin America, in cleared rainforest areas, what kind of policies and technologies will stimulate the shift from beef ranching to agrosilvopastoral systems? What kind of policies will be necessary to promote equity? In the highlands what kind of policies and technologies will promote appropriate use of natural resources and farming systems based on the comparative advantages of the native livestock species? In areas of intensive monogastric production around major urban centers, what kind of systems should be promoted to recycle wastes?

2. Commodity systems research. There are cases where specialized livestock systems are the key to promote the rational use of resources while contributing to meet population needs. In those cases, a production to consumption systems approach could be used to analyze bottlenecks and key entry points along a commodity chain (Navarro et al, 1992). Based on those results projects to develop alternatives may be designed. Examples of such situations might be the support to dual purpose cattle production systems in the tropics or the alpaca production systems in the highlands.

3. Animals, food security and biodiversity. Longer term global benefits for society at large have to be considered when planning R & D activities. Within this context, the contribution of animals to global food security and the appropriate use of species (domestic animals, wildlife and pastures) so as to preserve biodiversity merit special attention. A key challenge will be to find the kind of incentives to induce farmers to preserve in situ biodiversity. Also, given the long-term nature of the development of the large ruminant industry and the need for diversification to ensure food security; what kind of incentives should be provided to promote it?

4. Biotechnology. With the pressures to increase productivity while limiting the expansion of the agricultural frontier, new technologies are needed urgently. Biotechnologies could help to achieve the needed breakthroughs, such as in vaccine development, and improvements in reproductive efficiency which are of high relevance to developing countries. With the tendency to reduce the use of drugs, rusticity which is a common characteristic of native breeds may become more relevant in some situations.

Within the proposed strategies, trade-offs have to be recognized: short versus long term efforts, the promotion of intensive versus

extensive production systems, the emphasis on basic and applied sciences, the search for sustainability and productivity, etc. An appropriate balance needs to be defined based on the analysis of specific circumstances. Systems research provides the tools to understand different cases in order to improve decision making. Changes needed to promote development of the livestock sector depend essentially on the appropriate use of knowledge and information. Therefore, a critical element is the development of human resources in developing countries. It is through their active participation that appropriate decisions will be reached and changes will be promoted.

The difficulties of the past relate to the failure to grasp the whole complexity of the development process, which includes the relations of farming systems with larger systems (including the markets, the environment, the policy scenario, the social system, etc).

This problem goes well beyond the specifics of small farm development in less developed countries. It clearly is a part of the overall problem of mankind of learning to manage highly complex and dynamic systems.

The search for solutions to the agricultural problems in LDCs will benefit from the incorporation of whatever concepts and tools are developed worldwide to improve complex systems management. This is a major challenge to the agricultural sciences community.

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Table No.1: Population, Past Growth Rates and Projections

	Population (millions)	Average annual growth of population (percent)	
REGION	1990	1980-1990	1990-2000
World	5284	1.7	1.6
Developing Regions	4146	2.0	1.9
Sub-Saharan Africa	495	3.1	3.0
East Asia & Pacific	1577	1.6	1.4
South Asia	1148	2.2	1.8
Middle East & N. Africa	256	3.1	2.9
Latin America & Caribbean	453	2.1	1.8

Source: World Bank$_{(a)}$, 1992.

Table No. 2: Protein Consumption in Developing Regions 1986/88

Region	Total Protein 1986/88	Animal Protein 1986/88	Animal Protein as percentage of Total Protein
World	70.0	24.2	35
Developed Countries	101.3	55.2	54
Africa	51.1	8.0	16
Latin America	69.1	28.7	42
Near East	77.2	17.1	22
Far East	53.2	9.5	18

Source: FAO, 1989

Table No. 3:

Resources in Animal Agriculture by Developing Region 1989

		Percentage by region				
Resource	World	Africa	Near East	Far East	Latin America	All Developing Regions
Cattle (000 Hd.)	1281472	11.6	3.9	21.4	24.7	61.6
Pigs (000 Hd.)	846174	1.4	0.04	48.2	9.1	58.7
Poultry (0000 Hd.)	1057400	6.8	5.5	32.1	12.3	56.7
Buffaloes (000 Hd.)	140028	----	2.5	96.1	0.8	99.4
Sheep (000 Hd.)	1175524	12.3	12.4	17.6	10.3	52.6
Goats (000 Hd.)	526440	27.9	10.9	48.5	6.7	94.0
Camels (000 Hd.) *	19072	58.2	22.6	17.8	----	98.6
Permanent Pastures (000 Ha.)	3211959	19.7	8.3	14.9	17.8	60.7
Forest & Woodlands (000 Ha.)	4049041	15.6	2.3	11.1	23.7	52.7

* Does not include South American Camelids.

Source: FAO, 1989.

Table No. 4:

Animal Productivity in Developed and Developing Regions 1989

Region	Beef Carcass Weigth per Head (Kg/Hd)	As % of Developed Regions Prod.	Milk Yield per Cow (Kg/Hd)	As % of Developed Regions Yield
Developed Regions	93	100.0	4458	100.0
All Developing Regions	18	19.4	790	17.7
Africa	15	16.1	372	8.3
Latin America	30	32.2	1122	25.2
Near East	23	24.7	656	14.7
Far East	6	6.4	806	18.1

Source: FAO, 1989.

Table No. 5: Evolution of Milk and Meat Production in Developing Regions (Average growth rate 1986-91)

Region	Milk	Meat	Wheat	Maize
Developed Countries	0.5	1.1	1.8	0.01
Developing Countries	3.6	4.9	2.5	3.4
Africa	2.1	2.6	6.2	1.1
Latin America	2.3	4.0	-3.0	-1.0
Near East	1.8	1.9	3.4	4.5
Far East	4.9	6.0	2.7	5.6

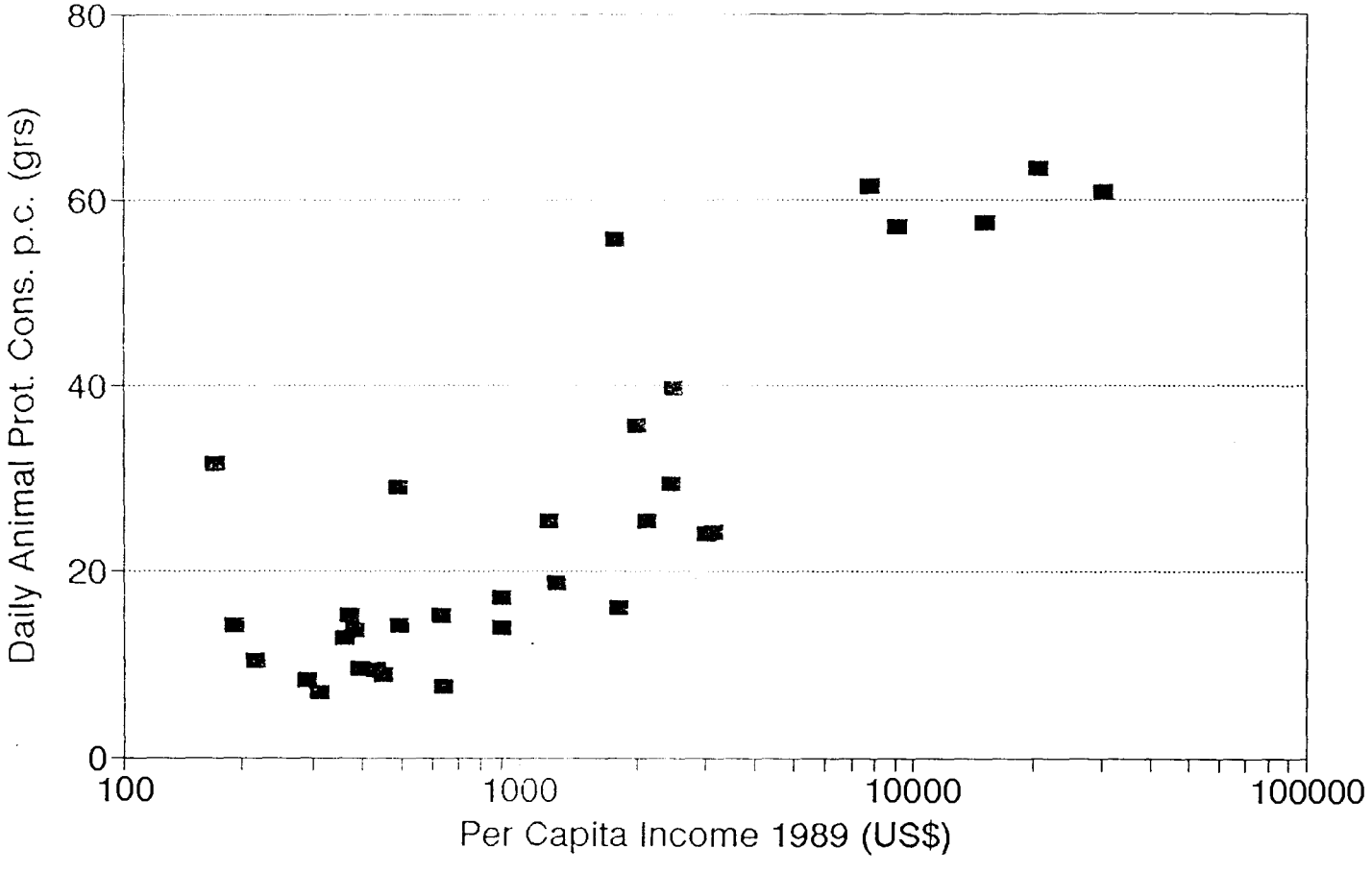
Source: FAO, 1992.

Table No.6: Price Forescasts for Selected Commodities (1990 = 100)

Commodity		1990 Prices (US$))	Real Price Indices						
			1991	1992	1993	1994	1995	2000	2005
Petroleum	$/10 BBL	212	80.2	77.8	74.1	73.1	73.6	84.9	80.2
Beef	$/MT	256	102.0	89.5	89.1	88.7	89.1	107.0	98.8
Wheat	$/MT	156	89.7	103.2	94.2	93.6	94.9	101.9	82.7
Maize	$/MT	109	96.3	90.8	86.2	87.2	87.2	92.6	75.2
Palm Oil	$/MT	290	114.5	127.9	131.0	121.7	118.3	104.5	91.7
Soybean Meal	$/MT	209	93.3	93.3	95.2	97.6	100.0	88.5	100.5
Timber Logs (Sapelli)	$/CM	344	89.8	91.9	93.6	94.2	95.1	100.6	107.0

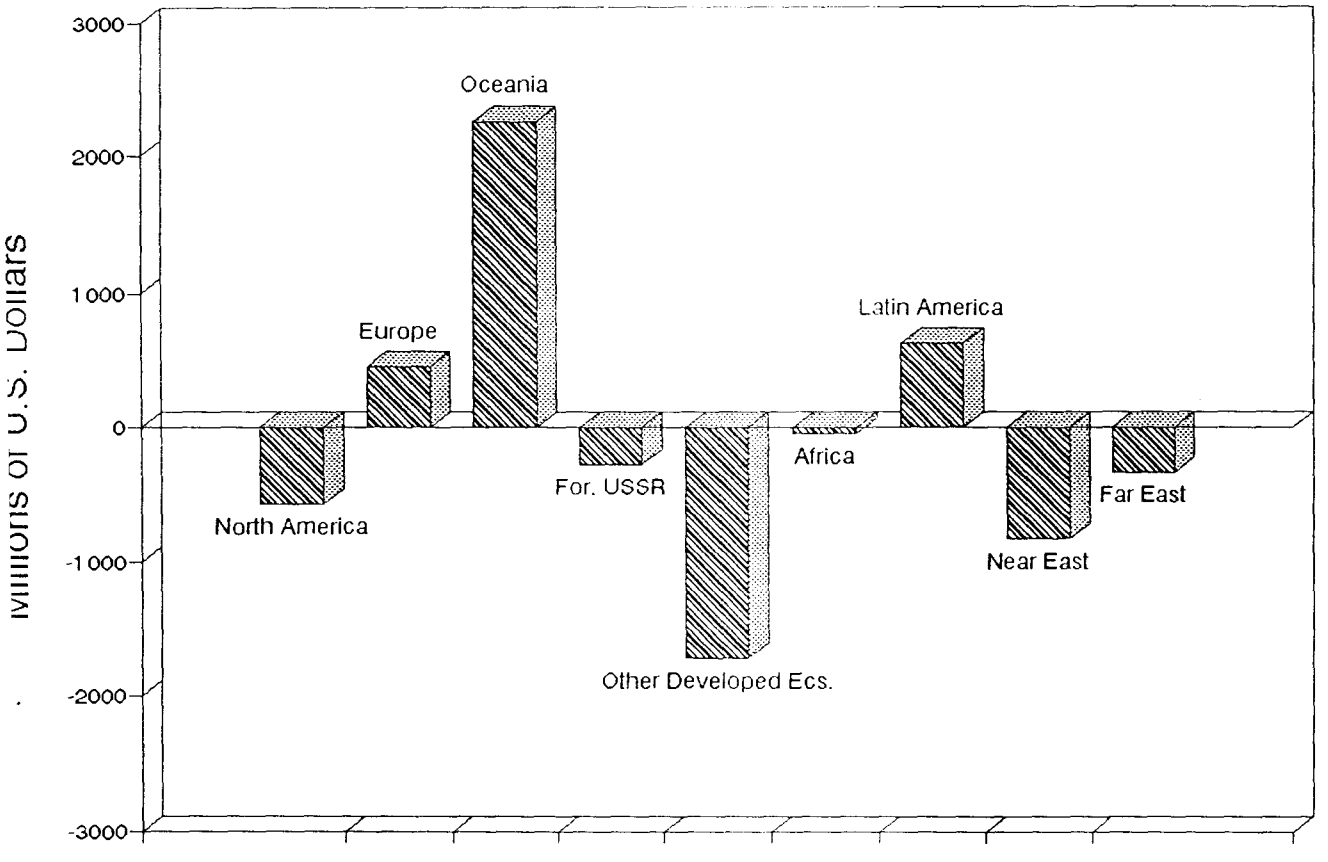
Source: World Bank$_{(b)}$, 1992.

Figure 1. Animal Protein Consumption by Income Level 1988-90



Source: FAO, 1992.

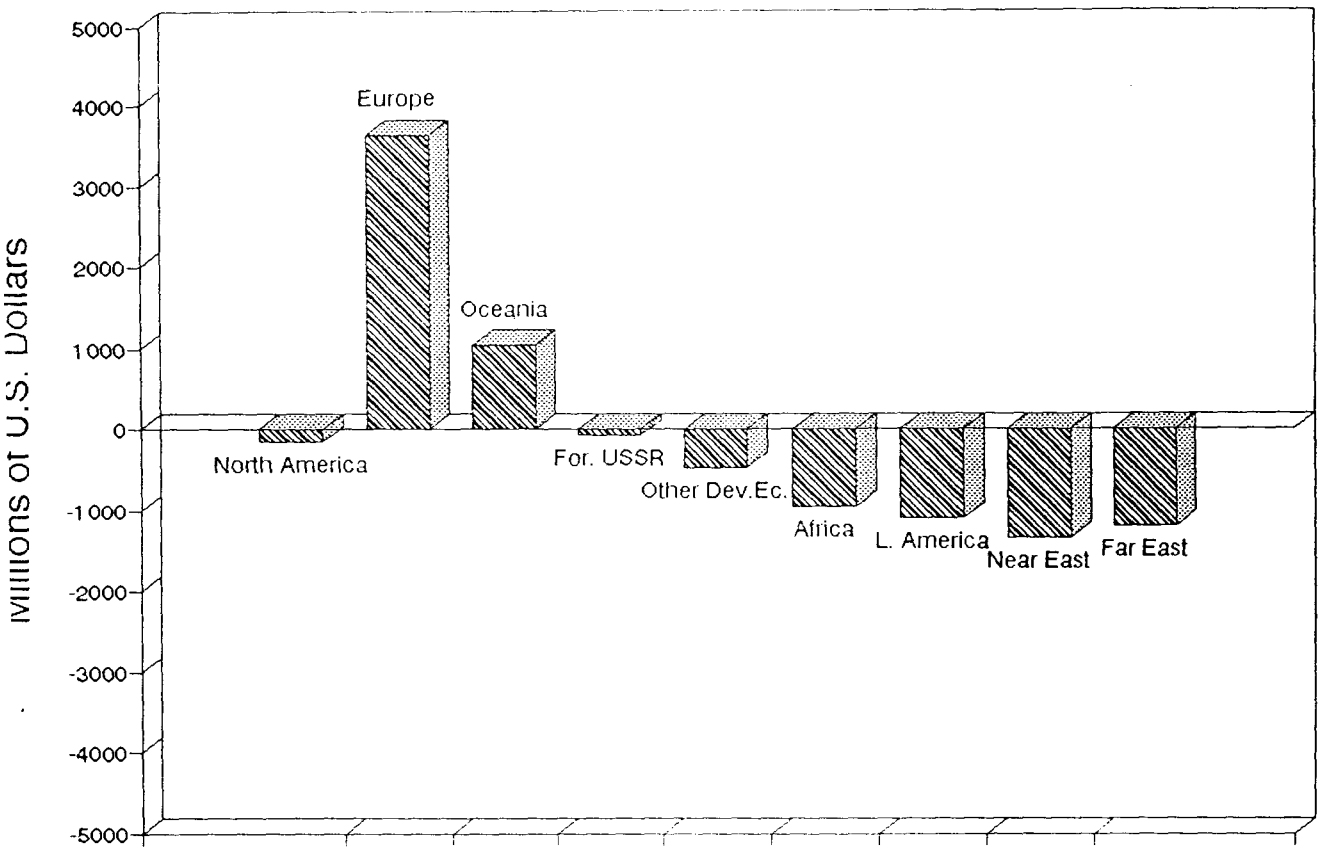
Figure 2. Net Trade(*) in Bovine Meat 1988-90



(*) Net Trade = Exports - Imports

Source: FAO, 1990.

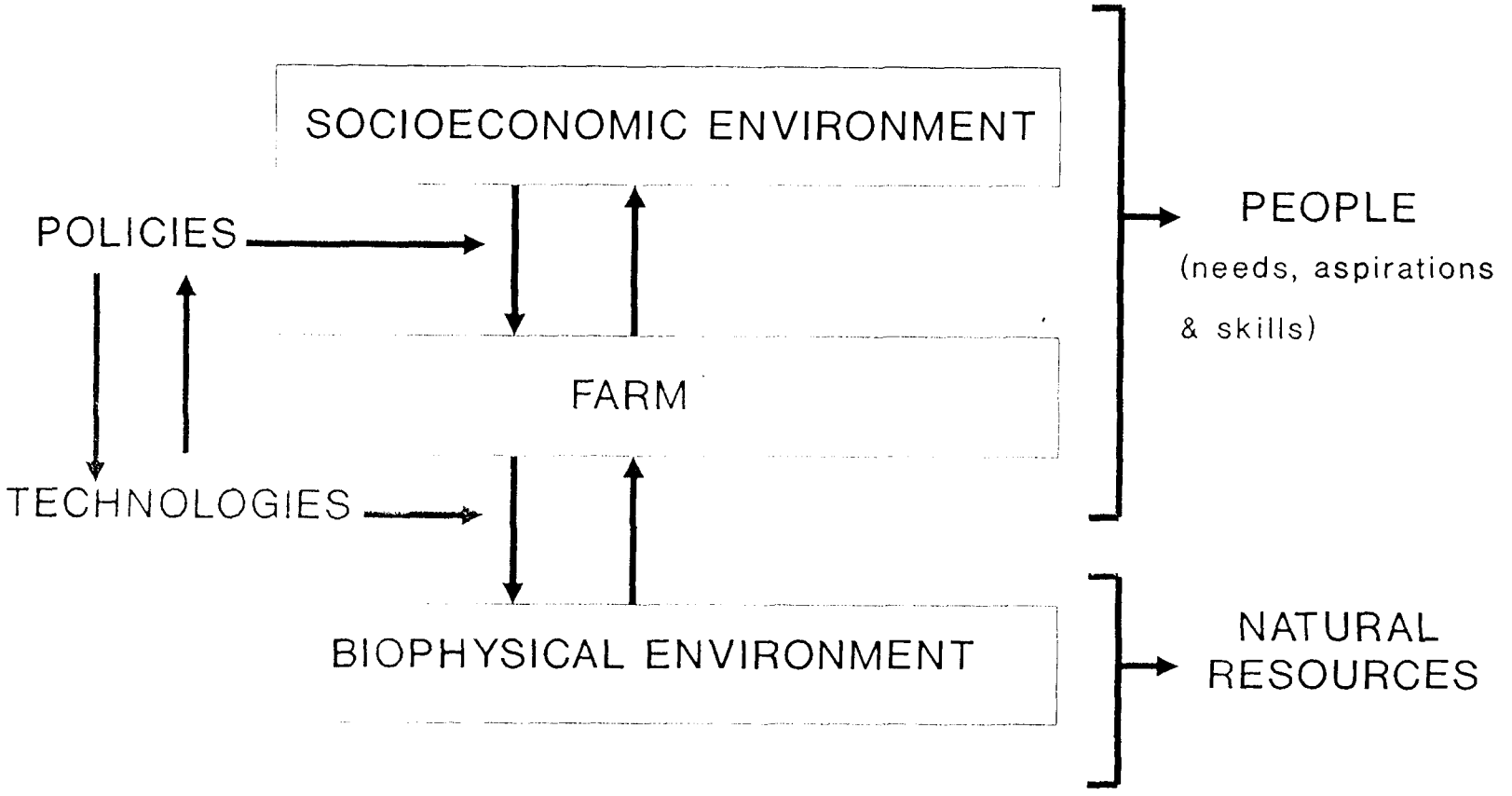
Figure 3. Net Trade(*) in Milk and Dairy Products 1988-90



(*) Net Trade = Exports - Imports

Source: FAO, 1990.

Figure 4. People, Natural Resources & Agriculture



Modified from Hart, 1991.

Figure 5. Systems Hierarchies

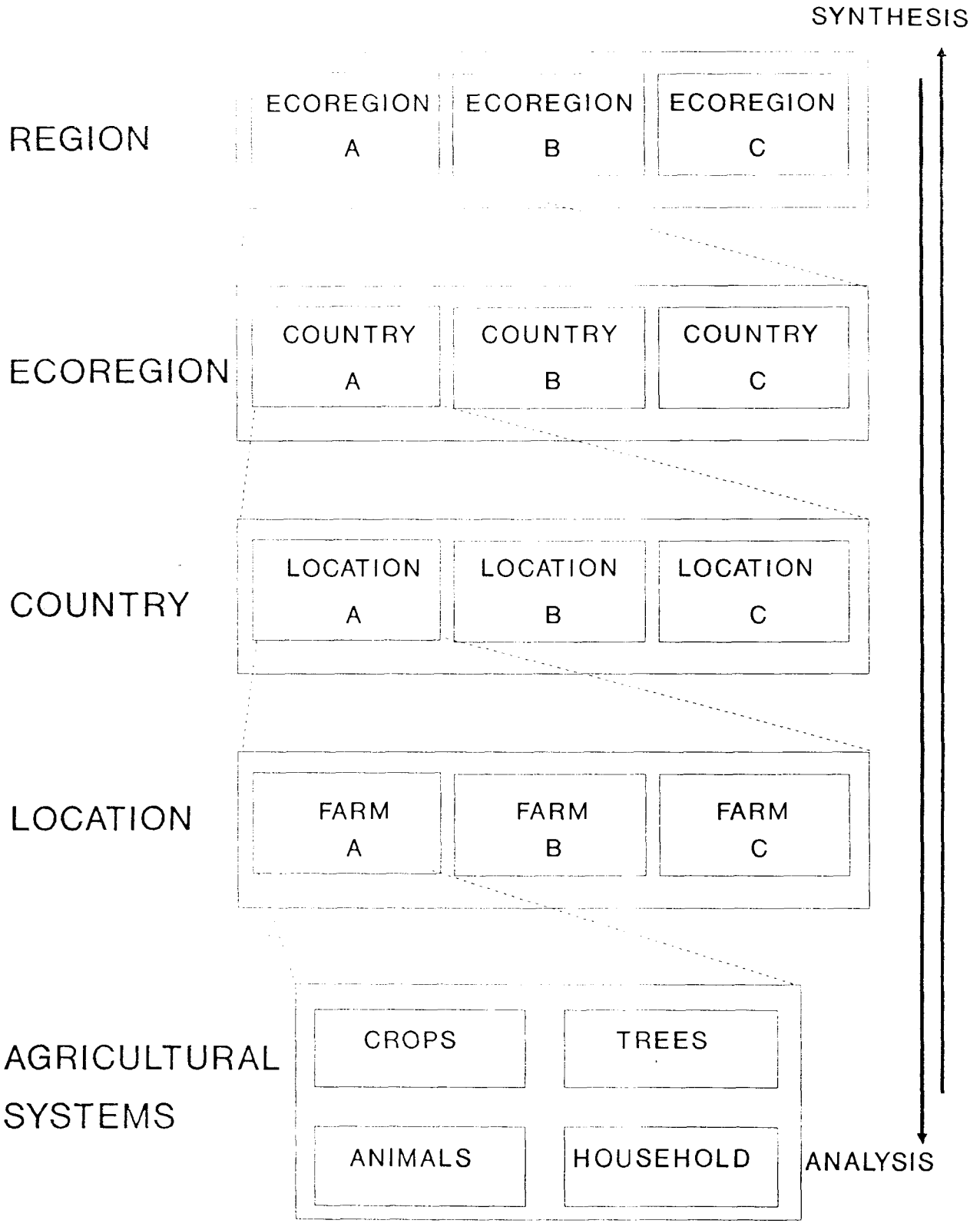


Figure 6. Whole Commodity Systems Approach