MATCHING LIVESTOCK SYSTEMS WITH AVAILABLE FEED RESOURCES

by

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INTRODUCTION

There have not been the projected improvements in livestock production in developing countries. This is mainly because of over-simplified goals stressing high individual animal productivity (based on criteria used in developed countries) rather than the role of livestock in the overall farming system. The socio-economic constraints that influence acceptance of innovations particularly by small farmers were also not adequately understood.

Technology transfer has been emphasized rather than development of local and available resources. Often the introduced schemes have created "dependence" on imports, in order to achieve projected target production. Fuel from renewable resources is becoming as important as food in some communities.

Education and research are essential tools in the development process, employing technologies and techniques which can be applied and must be appropriate in the student's own country.

New livestock strategies are needed which stress needs and identify the resources which are locally, or potentially, available. The livestock system must then be matched with those needs and resources.

Animal productivity or resource utilization?

In terms of output per unit of land, labour and feed there is no doubt that there are enormous disparities in rates of livestock production between the developed and the developing regions of the world (Table 1). It is equally true that the high rates of animal productivity in the industrialized countries have been achieved through a disproportionate use of the world's resources (Borgstrom, 1980), especially fossil fuels, marine fisheries and the protein rich cakes and meals:

- European livestock consume most of the oilcakes produced in developing countries.

- Developed countries consume per caput 50% more energy in the form of food but use 600% more energy for all activities than developing countries (Porter 1983).

It is relevant to this discussion to pose the question: why do we need intensive animal production systems? The argument used frequently by animal scientists is that biological efficiency is a direct function of rate of animal productivity. Almost unlimited goals have been set by animal geneticists for more milk per cow and more weight per day of age. The cost has been an increasing sophistication in nutrition to the point that only the most digestible feeds of high protein content (largely cereal grains and oilseed meals) are selected in the least cost formulations.

For the industrialized countries, mostly situated in regions with temperate climates, it has not been too difficult to secure the required feed resources since cereals and highly nutritious forages can readily be grown. Countries without available land to grow these feeds (eg: Japan, Taiwan, Israel, Arabian countries), because of their industrial base or wealth from oil, were able to import these feeds at relatively low cost and release them to farmers at prices often highly subsidized.

Developing countries by definition do not have these assets. Most developing countries are situated in the tropics. Their economies do not generate the necessary foreign exchange to import the 'quality' feeds used in intensive animal production systems. Moreover, one can generalize and conclude that there are insufficient world resources available - even if there was the wealth - for the poor countries to aspire to the degree of resource use now enjoyed by the industrialized world.

The challenge that faces the planners in the developing countries is thus formidable: how to raise the standard of living by the rational use of their own "national" resources, with only minimal help from resources from other parts of the world.

Technology transfer

Early development strategy assumed that "technology transfer" not "research" was the key to progress. But it has been proved that, at least in the field of animal production, the direct transfer of technologies from developed to developing countries has rarely been successful by any standard - neither technical nor economic.

The transfer of specialized animal production technologies from developed to developing countries, occasionally led to short-term gains in production of animal protein (eg: establishment of milk production colonies and intensive poultry enterprises on the outskirts of cities). However, the longer term consequences have been a "dependency" on imported feeds and the "superior" animals to take maximum advantage of the transferred systems. Another negative side effect of "imported technologies" has been the serious neglect of indigenous breeds and feed resources.

A specific example of a failure of technology transfer is the case of tropical herbaceous legumes. The reason is primarily because tropical legume/grass pastures are not sufficiently nutritious for dairy cows of high genetic merit which need high quality feeds such as cereal grains and maize silage; and they are too expensive for specialized beef production (even in Australia!!) which because of low productivity requires minimum inputs. Strangely, tropical legumes are likely to find their role in the development of the one cattle production system (dual purpose milk-beef) which, although the system of choice of tropical farmers, has been almost completely ignored by tropical scientists!!

Another example of transfer failure is the case of livestock feeding standards and nutrient requirements. From the economic standpoint, the fundamental flaw is the inherent concept of maximizing livestock productivity; which results in attempts to find (usually means importing) the feeds to match the livestock.

But there are also technical difficulties, especially with tropical feeds, where non-additive associated effects and interactions result in "prediction" of performance from feed analysis being a poorer guide than the rule of thumb methods of the practising farmer.

Socio-economic constraints to livestock production

It is not possible to introduce technological innovations in livestock production at the level of the smallholder without adequate knowledge of taboos (religious or otherwise), customs and the sociology of village communities. Subsistence farmers must first ensure their family's food supply. Only then can they think of improving the condition of their livestock. Thus, technical innovations, if they are to be successful, must be introduced within a framework which takes into account the following considerations:

- A low capital investment and an immediate financial return from the application of the innovation are prerequisites.

- The innovation must be relatively simple and should not interfere with normal farm activities, such as planting or harvesting

- There must be minimum risk associated with the livestock venture

- It should not be hazardous or arduous, unless returns are exceptionally high

- It should not conflict with religious or other cultural activities

Even given the existence of the right technology or innovation, the constraints to improving livestock production in developing countries are considerable. The application of scientific knowledge to the poorest people in the Third World does not seem to lie solely in the realm of the scientist.

Education and research as tools of development

Technology alone is not enough; in fact, applied indiscriminately and out of the context of the local situation, technology is harmful.

The objective of a rural oriented development strategy can be defined as:

- To increase the income and the well- being of the rural poor, which is synonomous with 'small farmers' and landless labourers as almost all rural dwellers are involved in one way or another with farming

The role of agricultural education and research in this development strategy is not easy to define. It was much simpler in the "technological" era. To increase animal productivity can be a simple exercise (eg: feeding high concentrate diets). However, when the technology has to fit into the socio-economic framework of a village, interactions and associated effects limit its application.

It is certain that not only the implementation but also the design of technologies, requires the involvement of multidisciplinary teams of scientists, and must be based on the conditions encountered by the recipient people. As a consequence, measuring the impact of a proposed innovation becomes more difficult as the goals broaden.

The scientists who participate in the evolution of these strategies must have, in addition to their particular specialization, a broad experience and understanding of development issues. In the words of Tarte (1984):

- "This is only likely to come about if the future architects of agricultural development strategies are trained in the environment where these same strategies are to be applied."

The long-term training of agricultural students from developing countries in advanced institutions overseas has also created special difficulties of identifying priorities for research and development.

A strategy for livestock development

The challenge to agricultural scientists is thus equally formidable as that facing the sociologists and economists; the task must be to maximize energy production from biomass while maintaining food supplies which should be done within the framework of an overall strategy which rates socio-economic issues of employment creation more important than technical yardsticks; and where "self-reliance" is to be prized over "self-sufficiency" (eg: intensive poultry production may make a country self-sufficient but not self-reliant).

The identification of needs and a careful study of existing resources - feeds, livestock and farmers - are essential first steps. Resources must be examined in the broadest sense of soils and climate and crops which might be grown. Livestock systems must then be matched with the resources in a way that aims for economic optimization rather than biological maximization.

New technologies may be developed; but it is more important to start with the improvement of existing ones. The present passion for "farming systems research" is a result of the belated recognition of the obvious - that Third World farmers are much wiser and more knowledgable than planners or livestock specialists when it comes to resource utilization.

Appropriate livestock techologies

Five examples have been chosen of technologies which appear to merit more widespread promotion. These are:

- The dual purpose system of milk and beef production

- Calf rearing by restricted suckling

- Production of feed and fuel from dual purpose high biomass-producing crops

- Integrated farming systems

- Urea/molasses supplements

(i) Dual purpose milk-beef systems

Dual purpose milk-beef production systems have been, and still are, practised by almost all traditional livestock farmers in developing countries; the motivation being as strongly economic (to pay the wages of the herd attendant) as nutritional (eg: in the Borana and Fulani tribes in Africa where human competition for the cow's milk is to the economic detriment of calf growth).

There are sound reasons for believing that the most economic way of meeting an increasing demand for milk and meat in developing countries is through improvement of the existing livestock production systems based on the multipurpose animal, rather than by development of specialized milk and meat production (Preston 1977).

The bases for the argument are:

- The relative consumption pattern of meat and milk in non-vegetarian communities

- Intensive milk production (more than 3000 litres/animal) competes for the same food resource base as monogastric animals and people

- The preference for high fat milk from buffalo particularly in the Indian subcontinent

- The increasing role of draught animals - and the need to produce suitable animals for this purpose from animals kept for milk

- In most countries, the need for flexibility because of inadequate marketing

Specialized dairy cows are highly efficient biologically. In contrast, specialized beef cows are inefficient, since their productivity is governed by their reproductive rate. This is always less than one offspring per year, which is considerably inferior to other meat producing species such as pigs, poultry, sheep, goats and rabbits.

Specialized beef herds have largely developed in countries where grazing land is readily available (eg: in parts of North and South America, Africa and Australia). In developing countries the increasing pressure on land implies that future priorities may favour sheep and goat production (because of their higher reproductive rate and multi-purpose traits of meat, milk wool and hair production). The growing of biomass for fuel in traditional grazing areas is another alternative that is of increasing importance.

A further consideration is that as population pressure for increased feed production increases, it may be necessary to decrease populations of oxen in favour of cows that produce milk and offspring as well as work. Dual purpose cattle are easily produced by inseminating native (adapted) animals with semen from exotic bulls that have been proven for milk production. Such bulls should preferably be from breeds or strains with good meat characteristics as this will help to confer "multi-purpose" traits (milk, meat and traction) on their offspring.

(ii) Restricted suckling

Unselected crossbred cattle with more than 50% of Bos indicus genes are reluctant to "letdown" their milk without the presence of the calf. But milk "letdown" is only a problem in intensive milk production units with the need for high-throughput, low-labour milking sheds such as the "herringbone" and "rotary" designs. Such management systems are inappropriate in the majority of situations in developing countries where herd size is 1-5 animals, where family labour is readily available and the maintenance of machinery is difficult. The major advantage of combined milking and restricted suckling, is that both cow and calf benefit (see Table 2 and 3).

(iii) Feed and fuel from dual purpose crops

The importance of developing fuel supplies from renewable resources cannot be stressed too highly. It seems logical that the humid tropics will be the focus of many such programmes. They offer much more potential than regions with temperate climates, firstly because of the possibility of growing crops all the year round and secondly because of the higher efficiency of photosynthesis in tropical plants.

A consequence of the rise in oil prices is that the difference in the value of carbohydrate as a source of fuel or food has narrowed. This encourages the growing of crops which can be used for fuel as well as food production, and is to the long term advantage of high biomass producing tropical plants such as sugar cane and leguminous trees. A previous disadvantage of these plants, as conventional feeds, was the high proportion of the crop in the form of lignified cell wall. With the new "fuel" option, the fibre becomes an asset instead of a liability.

The effective utilization of these "dual purpose" crops requires the application of fractionation technologies to permit optimum use of the end products (Preston 1980). The logic behind this is that the contents of plant cells (largely sugars) and the leaves (which are high in protein) are most appropriately used for feed; while the structural carbohydrates of plant cell walls are best directed into fuel. Sugar cane and legume trees are particularly suited for this purpose, the former providing the energy and the latter the protein; fuel is a by-product (or primary product) of both (Figure 1).

This development has opened up exciting new possibilities for tropical animal production systems, which promise extremely high rates of animal and unit area productivity based on truly indigenous crops and technologies (Sanchez and Preston 1980; Duarte et al, 1982; Fermin et al. 1984; Llano 1985; Mena et al, 1981).

(iv) Integrated farming systems

Integrated farming systems aim to optimize overall agricultural and livestock productivity from available resources through the growing of multipurpose crops, with recycling of residues and byproducts both as nutrients for animals and plants and also for fuel. Figure 2 illustrates how the basic natural resources of solar energy, rainfall, atmospheric nitrogen, soil and farm management can be combined in an integrated production system, which aims to optimize resource use with minimum waste.

(v) Urea-molasses supplements

All crop residues, which form the bulk of the diet of ruminants in many tropical countries, and natural grazings during the dry season of the year, contain insufficient nitrogen to provide the ammonia needed by rumen microorganisms for the efficient fermentative digestion of such feeds. In these situations, supplementing ruminant animals with urea can bring about marked improvements in performance or increase survival rates when droughts occur.

The main limitation to the application of this technology is the difficulty of adding urea to the diet in a convenient way, and the toxicity hazard of doing this incorrectly. Incorporating urea in solid molasses-based blocks has overcome these difficulties and has been widely accepted by village livestock owners and by pastoralists (Leng and Preston 1984; Preston and Leng 1985; Sansoucy 1986).

The choice of livestock production systems

The argument for developing intensive pig and poultry production is based on the high feed conversion efficiency of these species and their high reproductive capacity. Ruminants by contrast have the capacity to convert refractory carbohydrate resources, when properly supplemented, into protein of high biological value.

The important issues, especially in terms of feed resource utilization in most developing countries, are that the "superiority" of pigs and poultry is only apparent when grain based feeds are available at low cost. Additionally, these industries need high management skills and controlled environments (good housing with control of temperature and humidity, and adequate disease prevention). Without these safeguards, the improved genotypes - an essential component of the superior performance - have difficulty in surviving let alone producing under village conditions. These represent major constraints, and as they are tied to fossil fuel prices, will become increasingly difficult to resolve.

Efficiency in ruminants is not simply total feed use per unit of production since the basal component of their diet is frequently rangeland, a residue or a byproduct, which have little value - other than for feeding to ruminants. In this situation, efficiency may be regarded as the utilization of the supplement component - which has alternative uses (eg: for export, feeding to monogastric animals or even in the human diet). The comparison is then between conversion rates of 2 to 4 kg grain per kg liveweight for poultry and pigs respectively; and the conversion of supplement in a diet based on crop residues or byproducts fed to ruminants which can sometimes be less than 1:1 (eg: use of fish meal in molasses and ammoniated straw-based diets) and is usually in the range of 1 to 2 kg supplement per kg liveweight gain (Preston and Leng 1984).

Although the arguments in favour of ruminant-based livestock industries are complex, the major differences are in the relative needs for fossil fuel-based inputs which are much higher for intensive pig and poultry enterprises and may be almost zero in village-based ruminant systems. When valuable supplements are scarce, then ruminants certainly should have priority.

Conclusions

It is apparent that many of the livestock production systems in the industrialized countries are not appropriate for most countries of the Third World. To pursue animal production goals, characterized by specialization and intensification, results in the development of breeds of livestock and feeding and management systems which rarely are economic or technically successful under the conditions of most developing countries.

It is time to identify more appropriate objectives for agricultural development, of which livestock must be an integral part, and to establish the broad guidelines of a strategy through which these goals can be achieved. The primary aim of a new development strategy should be:

- To optimize overall agricultural and livestock productivity from available resources through an integrated technology which employs multipurpose crops, multipurpose animals, and recycling of residues and byproducts both as nutrients for animals and plants and also for fuel.

There are many components in the above development strategies for achieving the goals and some of these are summarized below:

- The matching of livestock production systems to the available resources

- The selection of crops and cropping systems which will maximize biomass production and nitrogen fixation with minimum imported inputs

- Development of simple processing techniques to optimize the use of different components of crops for different end purposes, such as food/feed for human and animal consumption and fuel

- The recycling of livestock wastes

- More efficient and widespread use of agriculture byproducts and crop residues as sources of ruminant feeds or directly for fuel

- The use of multipurpose animals such as cattle and buffalo that work, contribute milk and meat and, in addition, generate fuel, feed and fertilizer from their excreta.

- Incorporating into the production system appropriate non-ruminant species that are well adapted to tropical resources, byproducts and wastes (eg: ducks, rabbits and fish)

The key concept for bringing about these improvements centres on the optimal use of available resources, rather than maximizing individual animal productivity (Preston and Leng 1985).

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Table 1: Livestock productivity in industrialized (developed) and third world (developing) countries (FAO 1980)

	Industrialized	Third World
Population (10^9)		
Human	1.1	3.2
Livestock Unit (LU)	0.42	0.96
Meat production (kg/yr)		
Per caput	32	6
Per LU	84	20
Per ha	6.4	2.6
Milk production (kg/yr)		
Per caput	330	26
Per LU	865	86
Per ha	66	11

Table 2: Effect of restricted suckling on cow performance: comparisons (kg/d) were mostly during early lactation (8-12 weeks) until the calves were weaned (from Preston 1983)

Breed	Restricted suckling			Control (no suckling)
	Milking	Calf	Total	
Hol/Brown Swiss X Zeb[1,2]	910	560	1 470	218
Holstein	15.9	5.1	21	
Holstein[3]	3 424	-	3 424	2 340
Holstein	6.2	6.93	13.1	10.7
Holstein[3]	1 598	-	1 598	1 463
Holstein	7.8	6.8	14.6	9.7
F_1 (Hol X Zeb)	3.9	6.6	10.5	6.3
Sahiwal	4.3	2.7	6.9	2.7
Creole	7.9	2.7	10.6	8.8
Hfd X Hols	4.5	3.9	8.4	4.9

[1] Suckling throughout lactation
[3] Yield from 8 weeks to end lactation (no calf suckling during this time)

[2] Milking without the calf was in the same herd but in different years

Table 3: Effect of restricted suckling on the performance of the calf (from Preston 1983)

Breed	Growth rate, g/d		Milk conversion[1]		Authors
	Rest suck	Art rear	Rest suck	Art rear	
Crosses	464	277	-	-	Alvarez et al 1980
Holstein	770	500	7.8	8.0	Velazco et al 1982
Sahiwal & AIS Crosses	552	370	5.0	9.0	Fatah Ullah Khan et al 1984
Creole	317	413	8.4	9.3	Gaya et al 1977
Hereford X Holstein	497	353	7.8	11.4	" "
Holstein	862	582	5.9	6.9	Paredes et al 1981
Buffaloes	463	330	6.2	8.5	Anon 1983

[1] Milk consumed by the calf/weight gain, kg/kg

Figure 1: The sugar cane crop (for feed energy and fuel) and the legume tree leucaena (for feed protein and fuel) readily lend themselves to the "fractionation" strategy (from Preston 1980)

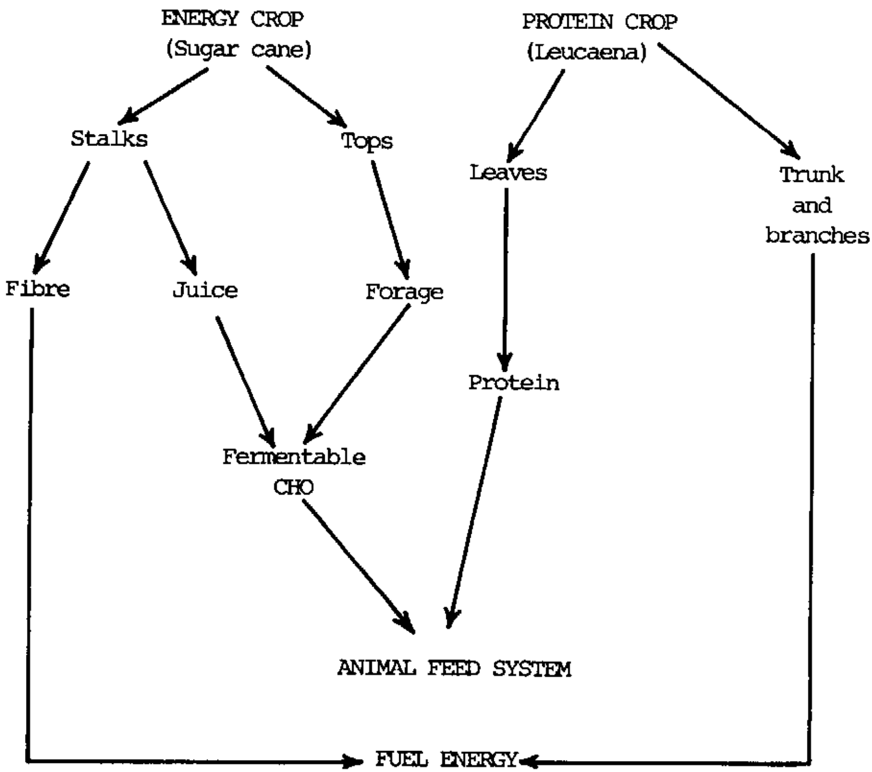

Figure 2: Flow chart illustrating the integration of crops, livestock, fuel energy (biogas) and fish and water plant culture (adapted from Preston 1981)