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CONSTRAINTS TO INCREASING LIVESTOCK PRODUCTION IN LESS DEVELOPED COUNTRIES: A LITERATURE REVIEW

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Introduction

By the turn of the century there will likely be 50 percent more people on the earth to feed than there are today [84]. There is general agreement that to achieve and maintain a balance between expansion in population and growth in the supply of food will be a difficult task. Various proposals have been suggested for increasing the food supply, but most have ignored the potential role of livestock. This neglect may be due to the belief that animals and humans generally compete for the earth's limited resources. Therefore, people should be given priority and resources now devoted to livestock should be used to raise crops for direct consumption. The basic argument is that animals are inefficient converters of plant materials to human food. Consequently, more calories and protein can be produced per hectare with crops than with livestock.

This reasoning neglects three important factors. (1) Food crops and livestock directly compete for land and other resources only in certain areas. Where they do, there is little argument about the need to concentrate on crops for direct human food use to the fullest extent consistent with food needs and economic considerations [38]. In many parts of the world, however, animals and food crops are quite complementary. Livestock, especially ruminants, can consume crop residues while providing fertilizer, draft power, hides, and even fuel.

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A combination of crops and livestock often results in more efficient use of labor than the production of either alone. Furthermore, there are large areas which are suitable only for grazing where the two do not compete at all. Therefore, the removal of livestock from the food chain would reduce the world's food producing potential. (2) Supplying enough calories to fill stomachs is only part of the problem as food quality is also important. While the greatest nutritional shortcoming among poor people around the world has been shown to be calories, not protein, in many areas the most acute problem is too little protein and protein of poor quality [45]. "Some staples such as cassava, rice, and pulse may be so poor in protein that a tiny child literally cannot eat enough of them to supply his protein needs" [98, p. 6]. Protein deprivation in young children can have a permanent adverse effect on their mental development [39]. (3) The efficiency of animal production per hectare in LDC's can be improved by efforts to control overgrazing of pasture land, restore ranges, reduce disease, lower calf mortality, and so forth. "... the developing countries have about 60 percent of the world's livestock, yet they produce only about 22 percent of the world's supply of meat, milk, and eggs" [93, p. 712].

The real issue then concerns the use of resources in the most efficient manner to provide the variety of needed nutrients. To the extent that policymakers in LDC's recognize that livestock have an important role to play in this respect, more attention will likely focus on easing constraints to animal production. With this in mind, the next section of this paper delineates briefly the major factors hindering livestock development in LDC's.

Major problems of livestock development

"In developing countries, livestock industries are so diversified that there is no single ameliorative measure for their improvement" [98, p. 15]. This is true among different regions and countries of the world and also within individual countries. Many of the livestock problems associated with nomadic tribes in certain areas of Africa, for example, differ markedly from those of more intensive crop and livestock enterprises in parts of Southeast Asia. Nonetheless, there are some problems which occur frequently in several countries: those associated with resource allocation both at the farm level and within the livestock sector; those related to cultural biases or informal institutions such as the common property system of property rights; those stemming from the lack of formal institutions or infrastructure such as marketing, and credit services; those of a biological nature such as animal health and breed selection, and finally special management problems such as a lack of record keeping.

While this list is by no means exhaustive and certainly many of the problems and the measures to correct them are closely related to one another, the remainder of this paper will focus on each of these problem areas individually and review approaches that have been taken in the literature to analyze their economic aspects.

Resource allocation

Deboer [20] says that analysis of factors limiting livestock development must consider the total farming system. Mosher [66]

states that the objective of each farm operator will seldom be to achieve maximum physical production within any one crop or livestock enterprise, but maximum profit for his farm on a whole. Meyer [61] emphasizes that the use of land and water resources requires intensive study of the multiple use concept. These writers are referring to the importance of achieving economic as well as technical efficiency both at the farm and at the sector level.

Deboer in his thesis dealing with constraints on animal production in Thailand makes the production relationships explicit for the farm and village level. He stresses the importance of considering the multiple roles performed by large animals in Thai villages. "These roles include use as draft animals, a form of capital accumulation, and the production of meat" [20, p. 1]. He samples three Thai villages and examines the various economic aspects of crop and livestock production. He calculates an internal rate of return to investment in livestock production. He estimates production functions and calculates marginal products to test efficiency of resource use, concluding that the village farmers are relatively efficient given the present technology. In his production functions, he first includes animal power as an input into crop production systems and then pasture and supplementary feeds as inputs into livestock production. He also examines the seasonal availability of resources.

Deboer suggests that the total resource base of a village sets a limit on the total bovine "biomass" that can be supported. This implies that the residues from an acre of rice support about the same weight of animal biomass as an acre of pasture. To

increase the biomass levels will, therefore, require a change in technology to increase crop production so a higher biomass level can be supported, or a change in technology to increase efficiency of feed use per animal.

Wu, in a study of the beef industry in the Pacific-Asia area concludes that any evaluation of beef production must include an investigation of the economy of the whole household [100]. This is due to the considerable diversification of objectives of cattle raising in Asian countries. Cattle are used as a measure of a farmer's wealth and as an investment. They are like a savings account and sold when cash is needed. Wu laments the lack of economic studies on the business side of farming at the farm level. There is a need for studies of economies of scale, choice of enterprises, optimum levels of fertilization of pastures, etc.

Both Deboer and Wu make it clear that in the Southeast Asian context, livestock production is an integral part of the total farming system. Total production potential of a unit of land would be less without that integration. Johnston [46] makes this same point and examines the roles of various species of animals in Asia. FAO says that 80 percent of the livestock industry in Southeast Asia consists of backyard or small holding production [91]. A large portion of the feed consumed by these animals consists of crop residues not suitable for human consumption. To the extent that livestock consume these residues for forage grown in areas where few alternative uses for land exist, there is little competition and in many instances complementarity exists between crops and livestock. Furthermore, when urea is used

to supplement the forage, animals may yield more protein than they are fed because they are capable of manufacturing it [84, p. 6].

Resources are often not allocated in the most efficient manner to exploit these complementarities. In Africa, for example, crop and livestock production are commonly exclusive enterprises in areas where a combination of the two could result in higher production of both [5]. There are, of course, many factors which influence any decision on how to combine livestock and crops. Oftentimes, cultural or institutional constraints hinder the reallocation of resources which might occur in response to changes in technical or price relationships [40].

In some areas of the world and especially on the African continent, a multiple use decision must consider the alternative of wild animals as well as crops and domestic livestock. "The wild animal population is rich in species of ruminants which can convert low quality herbage and bush, on a sustained basis, into badly needed animal protein more efficiently under some conditions than can domesticated cattle" [58, p. 341]. Wild animals are more resistant to many of the diseases which are prevalent in parts of Africa. Proper planning for their use is made difficult by the lack of data on the contribution they make to the economy (as food, employment, export earnings, etc.) and their costs (in terms of competition for grazing, damage to crops, spread of diseases, etc.). In some countries, they provide a high percentage of the protein [91].

Harthorn [33] makes the point that when the alternatives involve a choice between domestic and wild animal production, man's

ability to control the environment is often the deciding factor as to which is economically more productive.

The point is that there are numerous land use alternatives one can consider. There is little argument about the need to use land well suited for growing crops for direct human food use to the fullest extent consistent with food needs and economic considerations [38]. Livestock production often can be integrated with crop production, however, to achieve a more efficient allocation of resources. Furthermore, large areas of land not well suited to crop production at the present time are best devoted to grassland crops to feed domestic livestock or left in wild animal production. In many cases, the present grass cover could be upgraded with improved varieties and light fertilizer or lime applications.

Climate is, of course, one of the major land use determinants. For example, Jodha and Vyas [44] discuss the importance of livestock in dryland areas of India and emphasize that stability of income is often greater for livestock production than for cultivated crops because native grasses are adaptable to changing weather conditions. They feel that reseeding rangelands and adding more watering points can provide large payoffs especially since these are labor intensive projects.

A problem that arises when planners in LDC's attempt to formulate land use recommendations is the general lack of micro data and microeconomic studies which describe present production systems. Colombia is attempting to overcome this problem by making livestock surveys in various regions of the country. These surveys involve sampling producers to gain an understanding of current production

practices and problems [79].

The analysis of efficiency of resource allocation can occur at various levels and the type of study one does should depend on whom the recommendations are designed to influence. A few livestock related micro studies have been carried out in LDC's. Deboer's study is one example. Kaminsky [47] applies canonical correlation analysis to estimate production surfaces giving explicit consideration to multioutput production in his study of dairy farms in Argentina. He makes use of discriminant analysis in the grouping of farms. He discusses the problems of poor management and high seasonality of production. Linear programming is employed to determine optimal resource use or farm organization in studies by McGramm [57] in Argentina, Pandey [72] in India, Rojas [81] in Colombia, and Timm [92] in Venezuela. Aguirre uses aerial photography, producer surveys, estimation of cost and production functions, and discounted cash flow analysis in his microeconomic study of mixed beef production in Costa Rica [2].

At a more macro level, there recently have been studies of livestock at the sector level for a few LDC's. Nores [70], Jarvis [42], and Yver [101] have carried out econometric analyses of the Argentine livestock sector, while Kohout [49] implements a linear programming model. Nores' work contains a simultaneous equations model designed to analyze the short run structure and price formation mechanism of the beef cattle economy. Attention is given to the effects of exchange rate policies, maximum retail prices, and credit policies. Both Jarvis' and Yver's studies treat cattle as capital goods, which they are, and

producers as portfolio managers. Their empirical analyses show that long run price response of slaughter is positive but short run response negative because animals are withheld to permit an increase in future output. They disaggregate the sector and look at differences in response for various classes of animals. In a purely theoretical paper, Musalem [69] has shown under what conditions this negative short run elasticity is likely to hold. Kohout investigates the past and present cattle situation in Argentina utilizing a multiperiod linear programming model to analyze intertemporal cattle production response to price changes. Government policies are discussed which relate to the cattle sector.

An econometric model of the Brazilian beef economy has recently been constructed by Lattimore [50]. He projects the supply, demand, price, and export effects of changes in government policy instruments to meet certain objectives with respect to development strategy, inflation control, and balance of payments. Posada [75] has developed a simulation model to analyze the effects of production incentives on the decisions of farmers in the northern part of Colombia to adopt new methods. He estimates the effects of expanded regional production on farm income, government revenues, Colombian beef consumption, and exports.

Duloy and Norton [25, 26] have developed a large agricultural sector model for Mexico in which they approximate nonlinear relationships in a linear programming framework. While their model does not include the livestock sector, May [52] makes use of their technique in a study of the cattle sectors in Guyana. His model is composed of

a preprocessor, a stepped linear programming model, and a report writer which simulates the operation of the cattle sector and projects the effects of selected policies on the sector. Sample data were used to specify the model. The demand curve for beef and supply curve for purchased inputs were treated as exogenous and the supply of beef determined endogenously in the L. P. model. By maximization of consumers and producers surplus, endogenous prices and quantities representing a competitive equilibrium solution are generated.

A simulation model was developed for the Nigerian beef industry by Manetsch et al as part of a large simulation study of the Nigerian agricultural sector by a group from Michigan State [68]. The techniques developed in that work were later employed by Miller and Halter in a simulation model of the Venezuelan cattle industry [64]. They used an iterative approach which incorporated the results of interaction between the researchers and decisionmakers. Basically, they tried to show the consequences through time of the current set of policies and the consequences of the policy alternatives. Such simulation techniques can be useful when data are inadequate, goal specification difficult, or the sector is too complex to optimize with standard programming algorithms [19].

Cultural and institutional problems

Certain resource allocation problems are especially difficult to deal with because they are caused not just by factors such as poor management, pricing problems, or variable weather, but by cultural and institutional elements as well. Perhaps the best example of this

is the problem of overgrazing. "Up to a certain rate of use (in terms of tons of grass harvested or animal units pastured) grazing of pasturelands in one year may not increase the costs of taking the harvest the next year. However, from a certain stage onward, an increase in the rate of use will require costs of irrigation, fertilizer, rotation, or other practices of pasture management if the harvest is to remain unchanged" [95, p. 62].

In some cases, overgrazing is a seasonal problem because pasturelands will not support the same number of animal units in dry and wet seasons. This is a problem in Brazil, for example, in the areas where cattle are raised in an extensive manner [63]. Likewise in Africa, . . . "there is no balancing of stock numbers against the quantity of grazing available and, ultimately, the vegetative cover becomes degenerated" [30, p. 18]. In many cases, the overriding causes of the problem are cultural and institutional.

Overgrazing due to cultural factors is, perhaps, most prevalent in Africa, especially on the southern fringes of the Sahil. Numerous books and articles comment on the problem there [22, 24, 30, 85, 61]. Duckham and Masefield note that overstocking leads to soil erosion and denudation of pasture areas and arises from the social valuation placed on cattle by East African tribes. ..."The number of cattle owned, rather than their productivity defines a man's status. This attitude is reinforced by the customary use of cattle and goats to pay brides-price, without which a wife cannot be obtained, and by the traditional investment of wealth in purchasing cattle as a form of savings which provides a natural increase and does not lose its value

by inflation" [24, p. 354]. Schneider says that cattle play three principal roles in East Africa: real capital, money, and consumption goods [85]. Deshler says that livestock are a hedge against starvation. In a severe drought, the animals are eaten or are sold to government for grain. "Livestock are the one food available that can be stored on the hoof until needed" [22, p. 167].

In India, some have claimed that the sacredness of the cow has caused overgrazing. This has been disputed, however, by Harris who claims stocking rates are governed by other factors [32].

The system of property rights is an important determinant of stocking rates in many countries and a factor to be considered in the analysis of other livestock problems as well. "If a single person owns land, he will attempt to maximize its present value by taking into account alternative future time streams of benefits and costs and selecting that one which he believes will maximize the present value of his privately owned land rights" [21, p. 355]. Large areas of pasture land in the world, however, are grazed under a system of common property rights, i. e. ownership of the animals is private, but the resources on which they feed is common.

Gordon points out in his classic article on the theory of a common property resource, "Common property natural resources are free goods for the individual and scarce goods for society" [31, p. 135]. Since the grass is free for all users, it is valued by none and they will over-exploit it because if the individual saves some for tomorrow, it will be eaten by another man's animals. In other words, ownership is acquired through "... capture in the fastest possible way. Deferred use is

always subject to great uncertainty" [95, p. 94].

Mosher says that aside from the problem that no one has the incentive to limit the number of animals or otherwise protect and maintain the pastureland, there is also the problem that progressive farmers who want to improve their animals cannot do so. Under a common property system, it is difficult to control diseases or to control breeding so as to improve the herd. There may also be more labor involved in herding livestock to keep them where they belong [66].

Various articles point out the common property problem. Bottomley discusses the problem of overgrazing and common ownership in Libya [7]. Jodha and Vyas see it as a major deterent to improving rangelands and increasing livestock production in India [44].

In one of the few articles which attempts to quantitatively estimate the economic importance of changing a common property grazing system, Simpson and Young use cost-benefit analysis to demonstrate the feasibility of a new irrigation project on the Papago Indian Reservation in Southern Arizona [87]. They show that under the present "open access" system, the project is not economically feasible while under the assumption of limiting the increase in the number of animal units allowed, the project is feasible.

It is not always clear just when it is economically and socially feasible to change a common property rights system for any particular

case. General guidelines have been discussed by a number of authors. Dales points out "... a no policy policy makes sense if the cost of enforcing a positive policy is greater than the benefits" [18, p. 63]. Castle stresses that as long as the costs of internalizing the externalities due to common ownership exceed the gains from changing the institutional arrangements, then the change will not be made [16, p. 554]. Certainly the system of communal land tenure is not a pressing problem if a country has an abundant supply of land and the man and animal land ratios are relatively low. Oluwasanmi notes, "from the purely social standpoint, communal tenure acts as a strong cohesive force in an agrarian society" [71, p. 734]. He goes on to say, however, that the old system of tenure in Nigeria has become a "slow, ineffectual, and inadequate vehicle of effecting fundamental changes in agriculture" [71, p. 735].

Common tenure systems especially when associated with nomadic herding of animals probably developed as a traditional adjustment to fluctuating forage and water. The ability to move to where the water and forage were located was essential. Today as the animal and human population pressures grow, there are large areas of the world where new adjustments will have to be made in the tenure as well as other aspects of the agricultural system. Quantitative and qualitative information in these areas is needed and local research carried out to discover the development potentials. Results from such research could then be used in a programming framework to develop policies for overcoming local livestock problems and to frame a larger development strategy. This will require a multidisciplinary effort.

Pasturelands can be thought of as a renewable natural resource. These are two bodies of literature which deal with the economics of renewable resources which are relevant to the quantitative study of optimal rates of production and grazing of pasturelands.

The first group are studies which deal with the economics of grazing while not explicitly considering the possibility of common property aspects. Few studies of this sort have been conducted in LDC's, but several in the U.S. and Australia. McConnen examines the relationship between the pattern of use and future output from grazing lands in Montana [56]. He uses a simulation model and concludes that continued heavy grazing will decrease future pasture growth rates. Wright and Dent discuss some methodological aspects of simulation with specific reference to grazing systems [99]. They mention the need for interdisciplinary cooperation to overcome data problems. Arcus also discusses the uses and drawbacks of simulation for studying grazing management problems [3]. Dillon and Burley sketch a model specifying the important economic relationships for grazing experiments [23]. They describe the difficulties involved in estimating the simultaneous determination of the variables, and the role of time in the production process. Candler discusses how one decides what technique to use in examining a problem in animal production [14]. He suggests the use of linear programming or dynamic programming if the variability of the outcome can be ignored, and quadratic programming or simulation if outcome variability is the essence of the problem. Hazell [35] and Hazell and Scandizzo [36] have more recently suggested a method by which linear programming can also be utilized for problems involving

risk.

The second body of literature relevant to the economics of grazing incorporates the common property aspects into the model. Many of these articles use fisheries as an example, but in some cases the technique can be adapted to the grazing problem.

Gordon [31] and Scott [86] were among the first to discuss explicitly the economics of the common property situation. Since then numerous writers have looked at various aspects of the problem [8, 17, 27, 74, 88, 89]. Smith provides a theory of production from natural resources incorporating the common property aspect [88]. His model is static and uses a Lagrangian optimization technique which could be applied to various classes of resources. Brown employs control theory to get at the dynamics of natural resource production incorporating the common property assumption [8]. The results differ somewhat from Smith's static case. His article and one by Burt [10] lead one to feel that control theory may be an appropriate tool to use in examining the grazing problem in LDC's if enough data can be collected. S. V. C. Wantrup, however, explores briefly the static joint production approach and contrasts this with the dynamic models. He feels the former is more appropriate for practical approximations [95].

Most of the quantitative methods available are better suited to provide information on optimal rates of resource exploitation rather than operational means of achieving those rates. This is because cultural and political aspects as well as economics are important for the latter. The methods can indicate if changes are needed in grazing patterns to maximize present profit and protect future use of the resources.

Even if they incorporate some measure of the social cost of alternative methods of achieving the optimal rate of resource use, however, governments still find it difficult to apply the various tools to accomplish the change. Subsidies, penalties, education, and regulation of practices are among the possible techniques available to the government [95]. When the United States was faced with a common property problem earlier in the century, it passed the Taylor Grazing Act which accomplished conservation of our rangelands by, "(1) the withdrawal of public domain, (2) the establishment of grazing districts, (3) the administering of such districts by the Grazing Service of the Department of the Interior in cooperation with local stockmen, and (4) issuance of grazing permits to individual users" [95, p. 144]. Many have criticized this act, however, and certainly any specific method for an LDC will have to take the local cultural and institutional setting into account.

Marketing

Another severe constraint to increasing livestock production in many LDC's is an inadequate marketing system. There is little point in improving resource allocation on the farm or in a region or attempting to change cultural or institutional structures to increase production, unless a marketing structure exists to ensure offtake of the animals. The prices farmers receive depend partly on the efficiency of the marketing system which links them to the consuming centers. Transportation, holding, and adequate slaughter facilities, are aspects of marketing especially important to livestock production.

Wu says the major problems of livestock marketing in the Asian area are (1) lack of an organized structure at the farm level, (2) handling and storage losses, (3) inadequate facilities such as lack of water and accurate scales at the facilities, (4) slaughterhouses are unsanitary and (5) beef is not graded and all meat is sold at the same price so there is little incentive to produce high quality meat [100].

In a study in Colombia, Rivas found the main problems of cattle marketing to be (1) low prices for the producers, (2) excessive number of intermediaries between producer and consumer, (3) poor quality of transport, (4) seasonally poor farm access, and (5) lack of weighing of the animals [79].

In most countries, the marketing problems can be divided into two types; those associated with local markets and those of distant markets. Local problems are often associated with lack of adequate slaughter facilities and good scales. Transportation is a major problem associated with distant markets.

In areas of nomadic herding, F.A.O. is examining the possibility of inducing regular marketing of surpluses [77].

Credit

"Credit is important for the expansion of cattle production. Cattle investments generally take a long time to pay off and for this reason the producers may lack working capital and liquidity ... The pay periods do not coincide with the income receiving periods, and the producer is forced to sell his cattle to meet financial commitments. This situation may be because of the inavailability of credit, poor credit

planning by the lending institutions and poor use by the producer" [79, p. 101]. In Colombia, a supervised credit system is working on a limited scale and proving more successful than unsupervised credit although the farmers lament the restrictions imposed.

There are few studies of the effect of alternative credit systems on cattle production in LDC's.

Animal health

Animal health problems such as foot and mouth disease, rinderpest, brucellosis, and parasites, as well as other problems such as poor management, poor breed selection, low calving rates, and nutritional deficiencies all combine to reduce livestock productivity. Many of these are closely related but looking first at the health problems, there is evidence that a great deal of production is lost through diseases and parasites. An F. A. O. study of factors limiting livestock production in Latin America estimated that the equivalent of one-third the value of livestock production is lost annually through diseases and parasites [51].

Certain diseases are more prevalent in some areas than in others, and each disease has its own technical aspects which in turn determine its economic characteristics [54]. A study of the economic aspects of any given disease can become quite complex, and yet the economic aspects determine the level of the disease that should be tolerated. Obviously, complete disease control is a luxury few, if any, countries can afford given the multiplicity of needs for scarce resources. McCauley mentioned some of the factors which will have to be considered in any

study of disease control including: the epidemiology of the disease, the effect of the disease on production, the efficacy and optimal application of control procedures, the price effects of disease control stemming from increased supply and resource use, and the effects on import restrictions, transfer aspects, and other disruptive aspects. "The technical aspects must be examined along with consideration of the environmental conditions before the economic characteristics of the disease really can be defined let alone measured" [54, p. 3]. "... investigations should be done at suitable locations by workers experienced in the disease and the system of management, and should include numerous parameters of the study; e.g., epidemiology, economics, clinical investigations, pathology, and microbiology" [55, p. 215]. Clearly this calls for a multidisciplinary approach.

There have been few good studies published which use such an approach and some that have were done in developed countries. Power and Harris have done a cost-benefit study of alternative methods of controlling foot and mouth disease (FMD) in Great Britain using data from the 1967-68 FMD outbreak [76]. They compare a strict slaughter policy against control by vaccination and examine some external as well as direct effects. "On the basis of purely quantifiable factors, the slaughter policy is the more acceptable on any realistic set of assumptions. The differences between the two policies, however, are probably much less marked when allowance is made for unquantifiable effects" [76, p. 573]. They attempt to measure the disruptive effects on the distribution sector caused by controls on cattle movements. In general, they assume the benefits accruing to society from controlling FMD are

best measured as the losses avoided in the absence of the disease.

In another study, Ellis calculates average rates of return, net present values, and cost-benefit ratios for different approaches to controlling swine fever in Great Britain [28]. He uses actual direct costs for the 1963-66 period in estimating costs for a slaughter program, and uses cost projections from previous years to evaluate a vaccination program. The period for which benefits were determined was 1963-75. He attempts to measure only direct benefits and losses.

Other smaller studies have been carried out by the U.S.D.A. using mostly cost-benefit analysis [53].

Usually the diseases which receive the most attention in LDC's are those which kill the most cattle such as rinderpest or trypanosomiasis. Other diseases such as FMD and brucellosis, and parasite infections receive less because they kill less cattle and consequently the results of a control program are less spectacular. The economic losses resulting from their continuous interference with full productivity are probably greater than those from rinderpest or trypanosomiasis. One problem is that farmers often do not realize the magnitude of losses due to parasites or similar health problems.

There have been a limited number of studies of the economic effects of animal diseases in LDC's. Rubenstein makes a tentative analysis of economic losses due to FMD in swine in the Cauca Valley, Colombia, through the study of three cases [82]. She uses a simulation model to make a systematic model of the evolution over time of the swine herd of a hog farm. Then she identifies flows of costs and benefits to the farm with and without FMD. The comparison of the present

value of these two flows gives a measure of the economic losses in swine due to the disease. Since FMD does not occur in every year, she estimates the probability of an outbreak taking place in any given year, the probability that any given piggery will become infected once the disease is present in the area, and also the percentage of the swine herd which will be infected.

She says her results cannot be extended to measure costs of eradication of FMD for a large area unless the effects on species other than swine are also considered.

In another study, in progress, Rubenstein and a multi-disciplinary team are evaluating the economics of a campaign against FMD for a large region in the Northern part of Colombia. A simulation model is also being developed for that study. The specific purpose is to "quantify the losses due to FMD and to estimate the benefits, both private and social, associated with the ICA-USDA campaign against FMD in Area 2. The profitability of this intense level of control will be compared with the expected profitability of a less intense level of FMD control taking place in Area 2" [83, p. 1].

Jahnke has looked at the economics of controlling Tsetse flies and cattle trypanosomiasis in Uganda [41]. He uses cost-benefit analysis to compare various alternatives such as different levels of tsetse fly control, drug protection of cattle, introduction of disease resistant cattle, and utilization of wildlife instead of domestic cattle. Jahnke makes the point that tsetse fly control must be followed by cattle production immediately if the program is to be a socially beneficial use of development funds.

A vast area of Africa is infected with Tsetse flies. Research is presently being conducted in Northern Tanzania and at the international livestock disease research center in Nariobi on more economical ways to control the flies or the disease which they transmit [54].

In another study in Uganda, Ferguson [29] looks at benefits and costs of controlling East Coast Fever, a tick borne disease, and concludes that while control of the disease will indeed be profitable for most conventional producers and for the economy and is a necessary step for improving production possibilities, it will not be a panacea for the complex problems retarding production.

A brucellosis study conducted in Argentina by Bacigalupo et al estimates the losses due to brucellosis in a detailed fashion [4]. They measure only the direct losses, however, do not discount them, and do not compare the losses with the cost of the control program.

Peterson makes some estimates of returns to foot and mouth disease vaccination of beef cattle in South America [73].

Villegas discusses some of the economic losses due to animal diseases in North and South America, but his is not intended to be a rigorous analysis [94].

In general, there is a need for more detailed studies of the economics of animal disease control in LDC's. Unfortunately, a detailed study requires a lot of resources, often in the millions of dollars, because of the necessity of a multidisciplinary team which can evaluate the technical parameters as well as the economic aspects. Furthermore, many of the previous studies are weak in the way costs and benefits have been evaluated. For example pecuniary externalities

usually have not been considered when benefits and costs were calculated.

Breed selection

"There have been many abortive efforts to improve the livestock herds of Africa by importing exotic breeding stock from Europe and North America. With the exception of high altitude tropical regions where climates are mild, those exotic types have produced no benefits" [5, p. 13]. One of the problems decisionmakers face in LDC's is to decide whether it is better to import exotic breeds or alter the local breeding stock. Environmental conditions exert a very strong influence on animal productivity. Therefore, unless the environment can be altered, emphasis on the ability of the animal to survive adverse conditions should override productivity consideration. Emphasis should be placed on adequacy of food supplies, disease control, and better management, while upgrading the stock with animals adapted to a similar climate [30].

Management

The magnitude of the management problem in livestock development is difficult to assess. A basic lack of records often hinders the administration of the enterprise. This is compounded by certain practices such as poor management of soils and pastures, and lack of mineral supplements. Rivas feels this is a significant deterrent to increased livestock production in Colombia [79]. Certainly education plays a part in the ability of a farmer to manage his animals

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Peterson makes some estimates of returns to foot and mouth disease vaccination of beef cattle in South America [73].

Villegas discusses some of the economic losses due to animal diseases in North and South America, but his is not intended to be a rigorous analysis [94].

In general, there is a need for more detailed studies of the economics of animal disease control in LDC's. Unfortunately, a detailed study requires a lot of resources, often in the millions of dollars, because of the necessity of a multidisciplinary team which can evaluate the technical parameters as well as the economic aspects. Furthermore, many of the previous studies are weak in the way costs and benefits have been evaluated. For example pecuniary externalities

usually have not been considered when benefits and costs were calculated.

Breed selection

"There have been many abortive efforts to improve the livestock herds of Africa by importing exotic breeding stock from Europe and North America. With the exception of high altitude tropical regions where climates are mild, those exotic types have produced no benefits" [5, p. 13]. One of the problems decisionmakers face in LDC's is to decide whether it is better to import exotic breeds or alter the local breeding stock. Environmental conditions exert a very strong influence on animal productivity. Therefore, unless the environment can be altered, emphasis on the ability of the animal to survive adverse conditions should override productivity consideration. Emphasis should be placed on adequacy of food supplies, disease control, and better management, while upgrading the stock with animals adapted to a similar climate [30].

Management

The magnitude of the management problem in livestock development is difficult to assess. A basic lack of records often hinders the administration of the enterprise. This is compounded by certain practices such as poor management of soils and pastures, and lack of mineral supplements. Rivas feels this is a significant deterrent to increased livestock production in Colombia [79]. Certainly education plays a part in the ability of a farmer to manage his animals

in the most profitable manner.

Likewise, in the Asian context Wu writes, "The major constraint to the expansion of beef production in many Asian countries is undoubtedly the very poor standard of stock management practiced by most farmers. In the majority of cases, feed supplies are low in nutritive value, while, at certain times of the year, they are also inadequate in quality. This, of course, means that calving percentages are low, young stock make poor growth owing to lack of suitable feeding, cows do not calve until they are three years of age and, frequently, miss a full year in the calving cycle, while the fattening process is much slower than it should be" [100, p. 41].

Conclusions

In reviewing the various studies and comments that have been made on the economics of increasing livestock production in LDC's, one notices the lack of quantitative analyses that have been carried out. Various writers suggest how resources could theoretically be allocated more efficiently but often these judgments are not based on empirical evidence. This is perhaps due to the lack of description of the present situation in quantitative terms on which studies can be based. Furthermore, many of the technical problems of improving livestock production are more complex than those for crop production. Wu emphasizes, "... the urgent need for economic studies in all aspects of beef production so that development will be based on economic facts rather than on theories and willful thinking" [100, p. 9]. This is true for all types of livestock development, not just beef.

The potential is great for increasing livestock productivity, especially ruminant, in LDC's. The opportunity for improving nutrition of the human population in these countries is probably greater for livestock than any other means. In addition, many countries have a history of livestock use so it will be easier to upgrade their productivity than to change to other types of agricultural products. This is not to say that crop production should not be emphasized also. The key is to utilize resources in the most efficient manner to provide the variety of needed foods, taking into account the complementarities between livestock and crops wherever they exist.

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