PN-AAN-613/62
ISN-31786

Overseas Development Administration

SECTOR APPRAISAL MANUAL: BEEF

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June 1980

OVERSEAS DEVELOPMENT ADMINISTRATION

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A MANUAL CONTAINING KEY DATA, AND GUIDANCE AND APPRAISAL TECHNIQUES, RELEVANT TO INVESTMENTS IN BEEF PRODUCTION AND MARKETING

JUNE 1980

Foreword

This manual was written by Dr Morag Simpson of the Department of Economics at Leeds University, and edited by Dr George Gwyer of the Overseas Development Administration. Editorial assistance was provided by Dr Brendan Halpin of ODA and by Dr Cary Hendy of ODA's Land Resources Development Centre who also constructed Figure 1. Mr Brian Capper of ODA's Tropical Products Institute and Dr David Black of the Centre for Veterinary Medicine at Edinburgh University contributed the appendix on animal nutrition and Mr Peter Ellis and Mr Andrew James of the Veterinary Epidemiology and Economics Research Unit at Reading University the section on animal health. Valuable comments on earlier drafts were received from ODA's professional advisers including Mr Peter Stutley, Dr Basil Cracknell, Mr David Trotman, Mrs Judy White, Mr Gordon Bridger and Mr Ken Gubbins. Mr Stutley also provided the appendix on water. Mr John Grindle of the Centre for Tropical Veterinary Medicine and Mr Vincent Akonya-Abisa made helpful suggestions.

ODA wishes to record its appreciation to the following specialists with considerable experience in beef investment sector planning in developing countries, who were invited to a one-day seminar at ODM in June 1978 to discuss an earlier version of the manual:

Mr M E Adams	Private Consultant, Cambridge
Mr F Alder	Hunting Technical Services Ltd
Mr G Allanson	Wye College (University of London)
Dr G R King	University of Bradford
Dr W J A Payne	Consultant in Tropical Animal Production
Mr Stephen Sandford	Overseas Development Institute
Dr A J Smith	Centre for Tropical Veterinary Medicine University of Edinburgh
Mr A J Wynne	University of Leeds

Whilst not necessarily endorsing everything in detail in the text, they are in general agreement with it, and consider that it should make a valuable contribution to beef investment planning in developing countries.

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INTRODUCTION

Following the publication of the Ministry of Overseas Development's general guide to project appraisal in 1973, a series of accompanying manuals is being prepared, each of which covers a specific field. The present manual is concerned with beef production projects and should be used in conjunction with the first and key volume in the series - "A Guide to the Economic Appraisal of Projects in Developing Countries" (9).*

This manual is designed to provide broad guidelines to planners, administrators and others concerned with raising the productivity of beef production in developing countries. The prime objective is to improve the effectiveness of the planning process so avoiding the repetition of mistakes made elsewhere. The manual is written as a guide to assist economists in understanding some of the technical issues involved in beef projects, and secondly, to help livestock specialists to understand some of the economic issues involved in project preparation. The manual gives some indication of the type of technical information required under different circumstances, but is not in itself a technical manual. It is not intended to replace specialist advice. The hope is that the manual will serve as a basis for a common approach on the one hand by economists who are reasonably conversant with economic and social cost-benefit analysis but who have little experience of preparing projects in such complex fields as livestock, and on the other by animal scientists who too often play little or no part in relating in quantitative terms the costs and benefits of programmes or projects which they put forward from Departmental or Provincial level.

At the outset, a note of caution is given to the reader that livestock production systems <u>are</u> complex and often include factors which are unique to particular country situations. On some issues, some experts still hold opposing views.+ Therefore, local specialist technical and socioeconomic advice should be sought whenever possible.

The first part of the manual is sectoral in emphasis. One of the most widespread mistakes of the past in dealing with the livestock sector has been the carrying out of individual projects concerning particular facets of production (eg veterinary or

*Figures in parenthesis indicate a reference listed in Appendix 1.

+See for example the written exchanges between specialists of different views in the Pastoralist Network Papers (49).

water) without any reference to other determinants of production (eg grazing or markets). Sectoral investment programmes need to be identified, which may incorporate several individual projects. Thus the manual begins with a descriptive analysis of four main types of livestock systems in developing countries from which beef cattle emerge for slaughter. In many countries, there is a distinction between systems of breeding and rearing animals and those which fatten them prior to slaughter. Alternative pathways by which cattle are transferred between systems are identified.

Examination of the main constraints operating within each production system reveals opportunities for improvement in animal productivity. Such technical measures concerned directly with production need to be considered along with investments external to the individual production systems (through the provision of services and infrastructure) which facilitate interactions between them, particularly with respect to the marketing and transfer of stock. This part of the manual concludes with suggestions for successful combinations of project components derived from the lessons of experience.

The second part is concerned with the economic appraisal of beef projects. Beginning with estimation of demand and the internal market price structure in relation to allocation of supplies between domestic and foreign consumers, two examples of project appraisal are given: one for a commercial cattle ranch in which animals are bred, reared and finished for beef, and the other for a smallholder breeding and fattening operation. These two examples illustrate the dynamics of herd growth and the significance of choice of technical coefficients as well as the derivation of cost and benefit streams from the herd models.

The appendices provide more detailed information on particular topics. Included is a list of references as a guide to additional reading, and a glossary of technical and economic terms is given in Appendix 2.

Many of the examples given in the first part of the manual are taken from African experience. However, Asian and South American experience is also mentioned, and many of the principles enunciated apply to these country situations.

BEEF PRODUCTION SYSTEMS

A beef production system may be defined as a method of animal husbandry from which beef cattle for slaughter is an end-product. In applying this definition to developing country situations certain modifications are necessary. First it must be recognised that the system as a whole, covering the beef animal from conception to slaughter, where it is stratified can be divided into sub-systems where the breeding, rearing and fattening activities are separated geographically. Generally breeding and rearing are carried out on poorer land, while fattening operations are sited close to urban markets and/or sources of supply of crop by-products. Secondly, cattle owners in some components of the system may have objectives different from beef production. Thus pastoralists keep cattle principally for subsistence milk production and the sale of surplus males is essentially a secondary activity, while settled agriculturalists may use cattle or buffaloes for work purposes and beef is a by-product derived from old animals. The planner needs to consider the system as a whole and the ramifications of changing the productivity of one component on the position of another.

Here we distinguish four main types of production, each of which may be a sub-sector component within an overall system. This is derived from Payne (36) who has a more disaggregated classification. The systems are:

i. Nomadic pastoralism;
ii. Transhumant pastoralism;
iii. Settled smallholder agriculture;
iv. Specialist/commercial livestock farming.

Nomadic pastoralism

Nomadic systems are characterised by migratory patterns of animal movement in search of water and grazing on communally-owned low productivity pastures grazed by privately owned herds. The distances covered may be considerable and when feed and/or water are short, the herds move quickly from one water source to another. Nomadic pastoralism may be thought of as a form of large scale rotational grazing. The harshest constraint is that of shortage of rain. This cannot be measured by average rainfall, since it is the likelihood of a drought year occurring and the frequencies of such years which compels the occasional, exceptionally wide nomadic movement. It is because of these needs that nomadic tribes have always demanded areas which seem to be larger than one would feel necessary for their grazing. The people who own

cattle rely upon them directly for their food subsistence needs (primarily milk but also blood). They do not normally grow crops. Sale of cattle for fattening or slaughter is a by-product of the system in exchange for supplementary food. Nomadic pastoralism is a feature of the semi-arid tropics where human populations are less than 25 per square mile, eg the Sahelian zone of West Africa and the drier savannah regions of East Africa (Sudan, Ethiopia, Somalia, Kenya).

Transhumant pastoralism

Transhumance represents an intermediate stage between nomadic pastoralism and settled agriculture, where owners of cattle undertake some cultivation of crops during the wet season but their herds follow well-defined routes in the dry season to other grazing. Transhumant pastoralists interact with cultivators. As in nomadic pastoralist systems, the transhumant herds are important suppliers of milk, some of which may be sold to cultivators. Sometimes transhumant herds graze on crop residues and help thereby to improve soil fertility. Transhumant herds may also be the source of draught animals for cultivators. Transhumant pastoralism is a feature of the savannah zone of West, North-east and East Africa; and in parts of Western Asia and the Indian sub-continent. It is of particular importance in seasonally flooded areas, and where pastoralists can move to higher altitude range during the dry season.

Smallholder settled agriculture

Settled smallholder agricultural systems are characterised by a mix of crop and animal production, some aspects of which may be integrated. Cattle or buffaloes supply draught power and help to maintain soil fertility. These livestock are owned individually and may be tethered or stall fed, being fed principally on fodder and crop residues or grazed on local common pasture lands. Careful herding is necessary to avoid crop damage. Cattle fattening may be a source of supplementary income and employment for farm families based on the use of resources which have low opportunity costs - family labour and crop residues. With population growth, smallholders quite often cannot afford land for grazing. Zero grazing systems and those based upon crop by-products must then be considered. Draught animals may be sold for meat at the end of their working lives. Such systems are found in the Indian sub-continent, Northern Nigeria, Senegal, Uganda, Sukumuland in Tanzania and in many parts of South-east Asia.

Commercial beef producers

Ranches and feedlots, unlike the previous three categories, are owned by specialist livestock producers whose business is beef production (sometimes in combination with

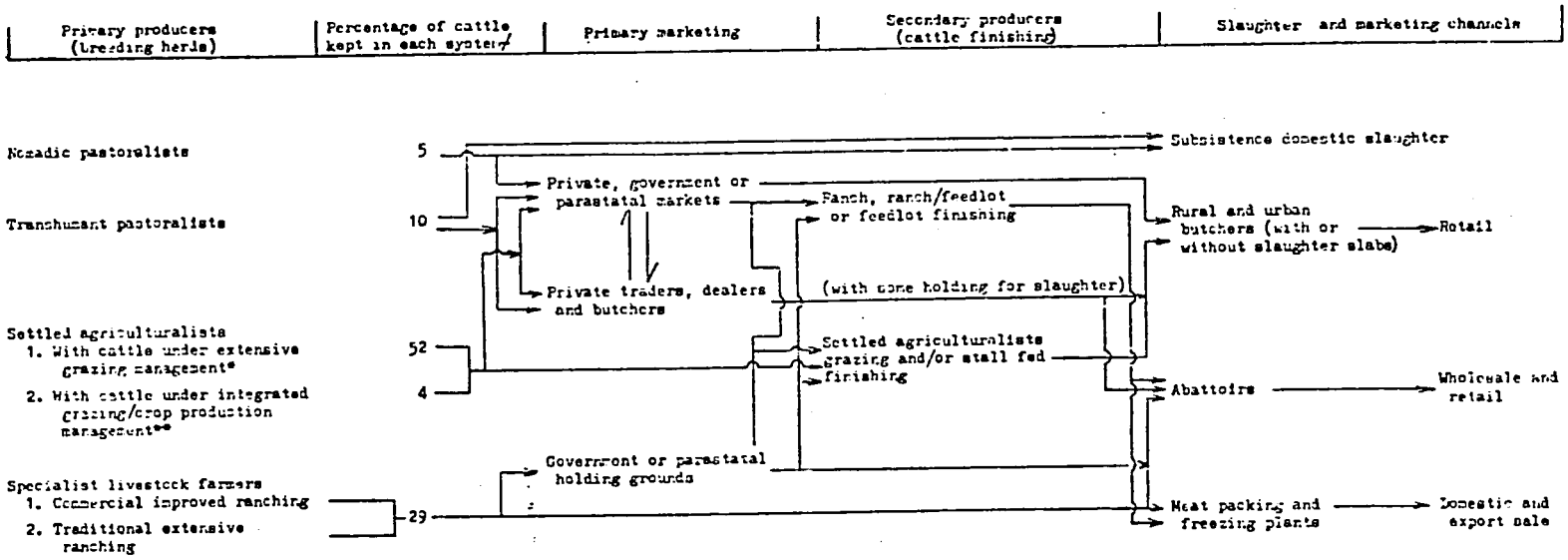
monocropping) as breeders, rearers, fatteners or all three. Herds and grazing land are normally owned by individuals, private or State companies or multinational business corporations, and boundaries are defined, usually by fences.

Ranching is often the commercial alternative to nomadism in the drier areas of Mexico, Central and South America, in the tsetse fly free areas of East and Southern Africa, and in Mindanao and Masbate in the Philippines. Physical conditions for beef production in Latin America are generally far better than in Africa. In Argentina, cattle can reach slaughter age on improved grasslands within two years, although in other parts of South America, three or four years is more common. Integration of beef cattle production with commercial sugar, coconut, pineapple and sisal plantations offers considerable scope for expansion in some tropical countries where the crop by-products represent cheap sources of feed. But expert nutritional advice is necessary, as many by-products, on their own, are deficient in important dietary factors.

Linkages between systems

Figure 1 gives a diagrammatic illustration of the alternative pathways from birth to slaughter that cattle may follow between the four types of subsystem defined above. To take an extreme example, an animal may be bred by a pastoralist, sold as a calf to a transhumant who rears a steer which is subsequently sold to a settled agriculturalist as a work animal, which is sold at the end of its working life for fattening prior to sale to an abattoir for slaughter. This animal would have been through four market transactions, discounting any sales between trader intermediaries whose function is to transport or trek animals between markets. At the other extreme cattle may be bred, reared and fattened on natural rangelands by ranchers or pastoralists. In Africa the process takes a long time because climatic conditions result in seasons of scarcity during which the animal's growth is set back. In Latin America, growth rates are more rapid, although animals are usually transferred to more fertile ranches for fattening prior to slaughter. Higher growth rates may also reflect breed selection in Latin America.

The planner will need to identify the more important systems in his particular country and their linkages. In doing this he should not neglect the contribution to beef supplies from systems which are not primarily concerned with meat production. An obvious example is the dairy industry when surplus males and barren cows are sources of stock for fattening up for beef. Other sources of beef in a developing country include aged work oxen. Cattle are the major source of draught power in



* Combining the migratory shifting cultivation, sedentary shifting cultivation and sedentary subsistence cultivation classifications of Williamson and Payne (1978)
** Combining the regulated lay farming and perennial crop cultivation classifications of Williamson and Payne (1978)
/ Derived from classification of Williamson and Payne (1978). Averages over all tropics and subtropics

FIGURE 1 Animal transfers between production systems

many developing countries and a useful additional source of income is to fatten up a plough ox or buffalo when it is past its useful working life.

In terms of employment if not in terms of actual livestock numbers, pastoralism predominates in few countries. In the majority, the distinction between pastoralists and livestock owning farmers is blurred by the fact that mixed farming, ie a relatively well integrated enterprise involving crop and livestock production, is the norm. In other countries, eg the "cattle complex" Bantu societies of East, Central and Southern Africa, farmers are involved in two systems, only integrated in some respects, which involve arable production on land individually allocated, and pastoral production on communal land, or on land to which they have access by virtue of membership of a family, clan or allegiance to a particular traditional authority.

As indicated above, linkages between different systems can be very important, and it is essential to understand these aspects which have a strong influence on development. Of these, access to grazing and water, and the location of grazing areas in relation to arable lands may be crucial, as can be the need for draught animals.

In a beef manual, it is clearly not possible to consider in detail the interrelationship between cattle as a source of draught power and as a source of meat (and milk) respectively. In many traditional societies the low offtake through institutionalised marketing channels may in fact be masked by slaughterings for family consumption or within the wider group at village level, as well as by unregistered sales in local markets. Many cattle, moreover, spend a part of their lives as draught animals and are then slaughtered for beef well past their prime. Efforts to increase offtake by reducing the average age of slaughter which do not take full account of the cattle owner's own draught requirements or social obligations to relatives and friends may, therefore, be misjudged.

In some African societies, productive female cattle are regarded as a useful interest-bearing asset and cattle generally as a suitable means of holding, and even displaying, wealth. Surplus cash, earned from non-farm employment, may also be invested in the purchase of more cattle. In some countries this may no longer be a wise investment. In Lesotho, for example, imports of breeding stock have increased in recent years, yet the national herd has continued to decline. Birth

rates have fallen and mortality has increased and it is evident that the land can no longer carry the stock that it once did. Due to the practice of continuous grazing the more productive grasses have been replaced by poorer herbage.

There is a strong tradition in Eastern Uganda and in most of Tanzania that the parents of a man about to be married should give to the prospective wife's parents a certain number of cattle, to include milking cows and males of working age and sufficient strength for draught purposes. To the extent that the emphasis in these customs is on the exchange of productive animals, it does not necessarily follow that such practices move contrary to normal market behaviour or that animals arrive at slaughter at much greater ages.

The existence of "multi-purpose" cattle in traditional societies does not imply, however, that nothing can be done to render the beef enterprise more effective, although it may make its achievement more complex. Thus, not all the livestock in the hands of an individual or the majority of those held by a village community are required for draught purposes and there may be scope for more selection and specialisation. Nor is it necessary, still less desirable, for cows in calf or with calves on the hoof to have to compete for grazing with the generality of the herd. The allocation of special grazing areas may itself be the first step towards stratification.

Trends towards intensification of systems

Common use of pasture and water is still standard practice in most of Africa and parts of Asia. Whether this will continue as cattle numbers and rural populations increase is open to question. In order to maintain social cohesion, attempts at retaining forms of communal social structures under various forms of group ownership are being tried. The historical development of cattle production elsewhere (North and South America, Australia) has been of individuals appropriating land as it becomes scarce (and hence valuable), fencing it and developing more intensive forms of production. While Africa has a different socioeconomic tradition, there are signs that the same process is occurring there as elsewhere, as private herds appear to be becoming larger and pressures from the owners to appropriate productive assets increase. These pressures redistribute resources towards the more successful and hence create serious social and political dilemmas within the rural sector. It is not yet apparent whether more socially equitable systems can be evolved which are as efficient in order to meet the increasing demand for beef. In Latin America the

antagonism between beef and agricultural producers is now largely historical since boundaries have been staked out fairly clearly in most countries. However in the remoter parts there is still conflict between subsistence producers and large ranching institutions.

The main factor governing intensity is the opportunity cost of the land. This depends on returns from other uses partly determined by soil and climate, together with distance from markets. With population growth and improved farming and transport technology, more land is being brought into cultivation and extensive methods of beef production are coming under pressure (44). Agronomic and plant genetic research have extended the areas in which crops can be grown, and population pressure has caused the movement of arable farmers into areas which are marginal for crop-growing. This movement has deprived pastoralists of some of their better grazing grounds. There is also competition from game and tourists in some countries of East Africa. The returns from land devoted to beef - especially the breeding and rearing sectors, are normally considerably lower than those from crop production. Limits to intensification are of course set by ecological considerations. Land in dry areas may be best suited to pastoralism and it would be a mistake to attempt enclosure into ranches, however large these might be. In higher rainfall areas, however, cattle production may need to compete in terms of returns per hectare with arable cropping, and in this way moves towards more intensive systems are induced.

The high opportunity cost of good land used for breeding and rearing, leads eventually to the geographical separation of those stages from the final finishing of fat cattle. When this happens breeding and rearing are commonly sited on land sub-marginal for cultivation. In South America and in East Africa, semi-arid ranges are a major source of immatures. The smoothness by which this somewhat extended system of beef production operates depends on adequate marketing arrangements for immatures together with health control measures to prevent the diffusion of diseases by cattle in transit from one district to another.

Alternatives to migration as a response to seasonal feed shortages include production of forage crops, conservation of fodder, and the provision of supplementary feeds derived from crop by-products. Such systems require arable cultivations and the fencing of land with the provision of water points inside the enclosures. In order to realise the full potential for increased productivity from these intensive systems it may be necessary to introduce improved breeds of cattle which are capable of responding to better inputs with higher performance.

The next major step in intensification is the intogration of a beef production enterprise into an arable farming system. In such systems beef cattle not only consume the crop residues but also graze rotational grasses often sown with legume mixtures. These rotational pastures help maintain soil fertility.

The ultimate in intensification is the purchase of fully-grown store cattle from ranches which have "backgrounded" nomadic immatures while they grow to full frame; these are then fattened in a short period on forage or silage supplemented by concentrated feeds containing cereal offal, oil cakes and molasses - all by-products of agro-based industries. Such by-products are sometimes exported from developing countries rather than being processed further into animal products, so missing the potential for additional value added. Equally, many large scale operations eg irrigated cotton, have been planned without consideration being given to keeping beef cattle on a ration containing cotton-seed cake, or even keeping milch cows to provide the milk needed by cotton workers.

Intensity is very much a matter of resource use rather than the size of production unit (46). For example, extensive grazing can range from a nomadic family with just sufficient head of stock to sustain life to large ranches covering thousands of hectares of land. Under intensive fattening, the size of the unit can range from 1-2 purchased store cattle being fattened on a small peasant holding to a large commercial feedlot with a turnover of say 20,000 fat cattle a year.

IDENTIFYING CONSTRAINTS

Payne and Smith (37) give a concise list of the major factors which lead to the low productivity of beef production systems in the tropics. "The factors include the direct and indirect effects of climatic environment, the genetic merit of the available livestock, the systems of animal feeding, the incidence of animal diseases, the skill, motivation and cultural attitudes of farmers - the efficacy of local research and extension services, the availability of credit, the existence of processing and marketing facilities, price structure and policy and the priority given to the markets by local governments".

Such a formidable list gives some idea of the task awaiting planners if a government decides to give greater priority to beef production. Obviously all these deficiencies cannot all be tackled at the same time. The planner, however, should not ignore the possible linkage effects. The high failure rate of cattle investment projects has occurred partly because linkage effects tend to have been ignored.

An obvious one is the link between nutrition and animal health, another the link between nutrition, age at slaughter and quality of a beef carcase. One important aspect which may not be so apparent is the link between nutrition and the genetic potential of cattle breeds - indigenous breeds in developing countries have been self-selected for survival under harsh natural environments, rather than by man for productivity. Selection by capacity for survival does not necessarily mean that there is no potential for higher productivity given improved management. To realise the potential of improved resources (feeds, cattle and better husbandry practices) then management may become a constraint. Consequently, thought has to be given to the strengthening of extension services and, with large projects, the building up of a cadre of skilled managers. The use of new purchased inputs may also have to be supported by credit facilities.

The removal of constraints is a complex process which can perhaps be envisaged as a stepwise progression in which productivity rises after the removal of one obstacle only to be halted by the next. In practice, a project is likely to adopt a "package" approach in which a group of major constraints is identified for attention; but the sequence in which these are to be tackled should not be lost sight of. For example, in projects involving pastoralists, one view is that a first need is to increase offtake rates through a marketing component. Once this has been achieved it makes sense to improve animal nutrition and animal health, so that the resulting increase in animal numbers can be accommodated without

overgrazing of the range resource. An alternative view is that improvements in animal health may be a necessary precursor of increased offtake, as until reductions in animal mortality are achieved cattle owners will be reluctant to sell 'surplus' animals.

Methods and approaches

The identification of constraints on beef production may be approached at national, regional and individual herd or ranch levels. In each case the essential requirement is to analyse and understand the production and marketing systems involved and the physical and social environment in which they have to operate. This allows both the identification of constraints and the prediction of the effects of development activities.

At national and regional levels, the types of constraint to be identified are those determining the distribution of livestock populations, farming systems and human population. These constraints include the natural environmental and climatic resources of the area as well as factors such as communication, transport and infrastructure. These in turn affect the distribution of production systems and the development of marketing networks to transfer livestock and their products from producing to consuming areas. In order to understand these systems, broad-scale reconnaissance surveys of land resources and land use may be required, involving the use of aerial photography and satellite imagery. Disease surveys, market surveys including marketing methods and demand, and the assessment of the support services available to the cattle industry from both government and private sources may also be required.

At these levels, considerable reliance will usually need to be placed on statistics available from the local authorities responsible for monitoring the cattle industry. The methods of collection and presentation of these data should be investigated to establish their accuracy. Some estimates of national or regional herd productivity may then be made, together with an indication of recent changes in overall herd size, distribution and performance.

At the local level, and for individual herds, a more detailed investigation of the production system will be required. This will include surveys of herd management and performance, either by single or repeat visit discussion and interview methods or, preferably, by longer-term livestock recording methods. Information from the monitoring of various environmental factors may also be required, such as

climate, natural grazing and water resources, disease, and the seasonal availability and quality of feedstuffs. Constraints may exist in the availability of financial resources, management expertise and technical advice. There may be a requirement for a limited trials programme to test the suitability of technology adapted from other environments; some assessment of the availability of research, demonstration and extension facilities and staff might then be necessary.

The analysis and comprehension of production systems and resources in this way leads to the identification of constraints by a process of comparison with broadly accepted levels of productivity and availability of resources and services. This process, however, is by no means a rigid comparison with standards. Physical and social environmental circumstances vary considerably between countries and regions; management techniques for the alleviation of constraints also vary widely. For each of the production systems defined earlier a range of performance levels and input requirements will apply. The identification of constraints within a particular environment is thus a process requiring experience and specialist judgement, particularly when the development of new and improved production systems is proposed.

Thus a logical approach to the planning process is first to identify the most important beef production systems in the country, and secondly to identify the major constraints on productivity both within each system, and in the infrastructure and marketing environments which determine animal transfers between them.

Water

Water is a primary constraint affecting pastoralist and ranching systems in semi-arid areas, as cattle have to be within one or two days' walking distance of their water supplies. Rangeland without water is a resource which cattle cannot utilize, although camels, sheep and goats may be able to graze within a wider radius of a water source (see Appendix 11).

Utilization of rangeland depends very much on water availability and its distribution over space and time. Water can be obtained from natural surface sources (rivers, lakes, springs) but in semi-arid areas these supplies will be sparse and rivers and streams are likely to be seasonal. Additional supplies can be obtained from the construction of reservoirs to store seasonal surpluses and from underground water by sinking wells and boreholes. Provision needs also to be made for watering points along stock routes, and water will be required where dipping or spraying is practised for health control purposes. Consequently it is not surprising that most cattle investment projects in semi-arid areas have a major cost component for the

provision of water supplies. Considerable care is needed however in the number and siting of waterpoints in order that the balance between the long-term grazing capacity of the rangeland and water availability is preserved, so that the balance between wet and dry season grazing is maintained, and to prevent the pastoralist's areas around water points being infiltrated by cultivators to the cattlemen's ultimate exclusion.

In more humid areas where more intensive systems of beef production predominate water is not such a problem. Where land is fenced, costs of water provision may be reduced by sensible design of piped distribution systems. For example, in Argentina, cattle paddocks are often laid out in squares to allow one watering point to serve four fields.

Nutrition

Nutrition is fundamental since beef production is primarily concerned with the conversion of nutrients of vegetable origin which are generally of high cellulose content and which cannot be utilised by a monogastric digestive system into meat for human consumption. This process involves the loss of the major proportion of the original nutrients since only a minor part of animal's food intake is converted into meat. A substantial proportion of the energy and protein intake is used for body maintenance whilst further energy is expended on activities, such as walking, required for daily living. Despite these losses, beef production in developing countries should not be thought of as a luxury, as under pastoralism and ranching the land resource has low opportunity costs, and feed for fattening under settled systems is often derived from crop by-products.

Not only is nutrition crucial to individual animal growth but it also has important effects on herd growth rates. Proper feeding at critical times can influence calving rates and weaning rates (38).

Under pastoralism, nutrition is largely determined by stocking rates. Overgrazing reduces the carrying capacity of the rangeland, as perennial are replaced by annual grass species. Some natural pastures will recover their productivity after one or two rainy seasons without being grazed; in other ecological zones, relief of grazing pressure can result in overgrowth of bush. Skilled professional advice is needed. Judicious investment in watering points may bring additional grazing lands within access. Natural pastures may be improved by the introduction of new species of grasses and legumes.

Nutritional constraints of the semi-arid zones include seasonal feed shortages, the high energy consumption of animals being trekked in a nomadic migratory cycle (continual movement also cuts down on the time available for grazing) and the slow growth rate of calves resulting from the consumption of their dams' milk by pastoralists who depend mainly on a milk diet.

Under settled smallholder agricultural systems, feeding practices are based on bulky crop residues such as straws, green leaves and damaged tubers, together with rough grazing, if available. For greater productivity these residues can be supplemented with whatever concentrates are available locally, including both the by-products of local traditional mills and oilpresses and modern agroindustries (eg oilseed mills, sugarcane factories, breweries). Planners should make an inventory of locally available feeds including their location and costs, so that nutritional advisers may make suitable recommendations. Given the high opportunity costs of land in the densely settled areas of the humid tropics, it is unlikely that crops will be grown solely for animal feed unless there is a serious soil fertility problem. The use of legume-based fodder and forage crops can do much to maintain both the nitrogen levels and humus content of the soil. With the tendency for fertiliser prices to rise with increasing energy costs, the use of legumes to fix nitrogen will probably become a factor of increasing importance.

As beef production systems become more intensive and a higher proportion of feed is either purchased or grown specifically for animal consumption (eg in feedlots) it becomes more important to take account of balanced diets and the costs of providing individual components of that diet in relation to alternative sources of feed. This is not to say that balanced diets are not important in extensive systems, but that the movement of herds may give a choice and opportunity to obtain scarce nutritional factors, eg cobalt. There are many areas of the world in which the soil and therefore the herbage are marginally deficient in some substance (or have toxic amounts of an element) and therefore are non-productive. The basic concept is to optimise the ratio of saleable animal product to feed input. To do this, however, requires a detailed knowledge of the nutritional requirements of cattle, and the nutritive composition of the available feeds, whether they are concentrates, bulky forages or grazing. A feed grown in a particular area may be very different in chemical composition from the analysis produced in tests based on temperate country crops. A further complication is that there are a variety of food evaluation systems used; one such system is described in Appendix 6. Whatever system is in use in a particular country, it is necessary to express the animal's requirements in the same units as are used in the local evaluation system employed for the analysis of the nutritive composition of the various feeding stuffs.

Given the nutrient contents of alternative feeding stuffs and their market prices, then it is possible to assess the cost per unit of the desired nutrient contained in each individual feed. Specialist advice will normally be required. Market prices rather than costs of production figures should be used, if the feed can be sold. With crops especially grown for livestock, yield per hectare is important since this will affect both costs per unit of the nutrients contained in the feed and the amount of nutrients produced per hectare. Ideally a crop should combine a low unit cost for nutrients with a high output per hectare, where land is a limiting factor. The possibility of crop failure should be taken into account as animal feedstuffs will usually be grown on marginal lands.

Once adequate information is available on the nutritive requirements of cattle, the nutritive composition of available feeds, and the relative costs of the desired nutritive units embodied in these feeds, it is possible to compute "a least cost food mix." [For further details, see Appendix 6]. For smallholder specialist beef producers, such calculations should be carried out by the relevant professional staff of the Ministry of Agriculture and the results made available to extension workers for dissemination to farmers. Unit costs should be revised regularly as prices and crop yields change.

Animal health

The effects of disease are obvious constraints on beef production. Even where local stock are partially immune or resistant, the economic effects may be severe. A variety of control strategies may be technically feasible for each disease, but the selection of the most appropriate strategy for a given situation depends upon the local production system, the resources which are available, local attitudes to veterinary services, and market requirements. A prerequisite of any animal health project is the cooperation of the producers.

Some animal health problems can be satisfactorily controlled on an individual herd basis, but epidemic diseases usually require action on a national or international scale or at least an agreed national policy, so that disease control becomes a project in its own right.

The economic importance of many health problems depends on the production system, and the type of animal (26). Foot-and-mouth disease, for example, is rarely important in indigenous nomadic cattle because frequent challenge maintains partial herd immunity, but may be more serious in settled stock, and disastrous in high grade

exotic stock. Where changes in a production system are contemplated it is important to anticipate the animal health problems which may arise as they can render the project uneconomic. This entails studying existing systems in the same area, or trying to extrapolate from experience in other regions, and also renders essential a diagnostic service, including laboratories. Pilot projects can be of great value in determining what animal health control measures may be necessary and the practicability of applying them.

While the control of epidemic disease is largely a matter for the government's veterinary services, the cooperation of producers is essential in bringing cattle for inoculation, notifying disease outbreaks and obeying quarantine regulations.

As the great epidemic diseases come under control, it becomes apparent that there are other constraints of disease which are not so readily perceived, as they do not make animals obviously ill or kill them. Examples are the internal parasites. No government policy can deal with these, although they may cause immense loss of production. Local strategies involving periodic medication with anthelmintic drugs (with reference to the rainy season) and alterations in husbandry practices need to be worked out by veterinarians with reference to local conditions.

Producers themselves should adopt health routines as advised by local veterinary services; the most important being the regular effective dipping of cattle to control ticks which are parasitic on the animal and also transmit diseases. Drugs for the control of internal parasites can also have dramatic effects on productivity, but attention needs to be given to the timing of treatment in relation to season. Crushes are important since they enable animals to be held for inspection and treatment. The provision of dips and crushes features in many investment plans. Dips by themselves can instil false confidence: there must be adequate testing and supervision, and sufficient provision of recurrent expenditure for their maintenance. Clearly the provision of veterinary services is more cost-effective when animals are kept under more intensive settled production systems where there is ready access to laboratory diagnostic facilities. Equally, there is little point in promoting improved animal health under pastoralism on an already overgrazed rangeland resource, unless it can be shown to create the conditions for an increase in offtake rates.

Selection of breed

The question of introducing a new breed of beef animal or upgrading existing stock by cross breeding is one that has greater relevance to the more intensive systems

of production. Animal productivity is a function of genotype, nutrition and environment. It is generally agreed that the beef breeds from developed countries have a greater potential for live weight gain under optimal conditions, while the indigenous cattle from developing countries have a greater potential for reproduction and survival in their local environments. Consequently in the past, emphasis has been given to crossing local cattle with imported exotic breeds in the hope of obtaining the desired higher output potential coupled with the ability to survive and reproduce.

Importing exotic foundation stock and crossing with local breeds, requires professional expertise both to control the process and evaluate the results. Such a programme obviously will require time. Recent thinking is in favour of identifying the constraining factors in the environment (climatic stress, internal and external parasites, diseases, and nutrition) and then to try to select cattle with the appropriate genotype to meet these constraints. Such an approach is a matter for the professional staff of a government department, to initiate and control, as is the direct importation of exotic stock for production purposes.

Management and extension

The qualities required of management in beef production are numerous and for the most part are obtained by experience rather than by formal training. The measurement of management performance is found in the herd coefficients of calving percentages, mortality losses and rates of liveweight gain. The pastoralist, whose objectives are more in terms of survival in the difficult environment of the semi-arid tropics than in terms of profit maximization or rates of return on capital, has to make decisions concerning the age and sex composition of the herd in relation to his assessment of the grazing capacity of the rangeland and rainfall, decisions of when and where to move in relation to the likelihood of finding water in the dry season, which animals to cull and when, etc.

The ranch or feedlot manager with a greater commercial orientation and a greater control over the natural environment including feed and water, has equally difficult if more sophisticated decisions relating to the time of buying and selling animals for breeding or fattening in relation to market prices, selection of new bulls and culling of old ones, time of the year to get cows to calve, which cows to cull[1], selection of feedstuffs, proper feeding of cows at mating and during pregnancy,

1 (in the Philippines it is said that ranch hands tend to select thin cows for sale on the basis that they are unthrifty when in fact they are thin because they have produced a number of calves and should be retained because of their fertility)

proper nutrition of calves pre- and post weaning, detection of disease and knowing when to seek veterinary advice. These decisions may be divided into those which are the domain of the stockman to do with the herd and its growth, and those of the market manager to do with the purchase of feed and the buying and selling of stock. The success of any programme depends to a large degree on the quality of management regardless of the size of the production unit.

Extension services are most likely to be important for smallholder producers for whom beef fattening is a new enterprise. Where small units are concerned, local operations may need a high degree of supervision and advice, especially from livestock husbandry experts and range and fodder specialists. Consideration should therefore be given to the expansion of such services, with due regard to a suitable ratio of extension workers to livestock owners, and adequate provision of transport. In the Solomon Islands for example, cattle introductions have been limited to areas close to roads or wharfs where adequate services can also be provided. These include extension, veterinary and marketing services. Even so, herds tend to be small and government staff are often hard pressed to give farmers the support they need. Where possible farmers are encouraged to form companies or co-operatives, so increasing herd size.

With large production units, past failures can often be ascribed to management weaknesses. Hence some thought should be given to the building up of a cadre of experienced local managers. A major beef development project may need to include a specialised training institute for technical and managerial staff for both the public and private sectors and also provide in-service training for extension workers and short residential courses for producers and managers.

Marketing

Producers will be required to carry new responsibilities in programmes to raise productivity, so they need to be convinced that they will benefit materially from their exertions and the additional risks incurred. Hence the importance of the levels of producer prices and in remoter areas, the availability of consumer goods on which pastoralist producers can spend their new earnings.

Producer prices should both reflect realistic demand and supply conditions and provide adequate incentives. In free market conditions competition should be encouraged to keep down distributors' margins. A strict watch should be kept on the emergence of buyers' "rings". Where the government is concerned with fixing

prices in accordance to carcase grades, the differential between higher and lower grades should be watched especially, as it is the lower quality grades which will be most in demand by the mass market in developing countries.

In African pastoral societies there is usually a traditional network of cattle traders, often of a different tribe from the pastoralists, who work on what may appear at first sight to be excessive margins, but they take price and animal mortality risks in carrying animals over space and time (4). A marketing system based on sales over a weighbridge can do much to give pastoralists better prices for their cattle, especially if coupled to the dissemination of market prices by the national radio network.

A free enterprise system is often to be preferred to a state-controlled marketing system, but in either case attention should be given to the actual costs of marketing. Generally the role of Government in marketing should be a minimal one confined to veterinary inspection to prevent disease spread, some minimum intervention in primary markets to discourage buyers' rings, and maintenance of transportation facilities (trains, ships, roads) to enable animal transfers to occur expeditiously. Investment in physical infrastructure at primary and secondary markets, such as pens, may yield a low return, and is unlikely to be worthwhile.

Cattle may be moved long distances between breeding areas, fattening areas and final points of slaughter. During such journeys, opportunities can be taken to hold the animals in quarantine grounds en route, in order to prevent the spread of cattle disease from one part of the country to another. For the export of meat it is vital to have for slaughter stock which has been certified free of disease. Extra holding grounds may be required for keeping cattle a few days before sale or slaughter. The provision of holding grounds requires feed, water and normally fencing.

Often in Africa cattle are trekked on the hoof to markets, incurring losses in number from death and theft, and losses of body-weight on the part of the survivors. Damage done by cattle trespass is also common when cattle are moved through cultivated areas. In considering alternative transit methods it is advisable to base cost comparisons on both direct and indirect costs, taking into account loss of body-weight. An advantage of trucking cattle is that they can be moved through non-disease free areas provided they do not leave the truck. A quarantine area straddling trade routes can keep cattle from markets for more than a year. Tsetse control measures, however, may be necessary in tsetse fly areas.

Stock route improvement is another way of reducing losses from trekking. This involves demarcating a corridor of land with grazing on either side of the main track, and with water, extra feed supplies and veterinary inspection stations available at regular intervals. In Latin America, animals are usually transported by road or rail.

Local and terminal sale points provide focal points for cattle sales if such points are not also used for the collection of taxes. Public sale will enable price information to be diffused and should help competition among buyers. Prices are more meaningful if related to cattle weights so the provision of weighbridges may be desirable. Ultimately payments should be related to the productive potential of the animal, so that less is paid for a big old cow than for a young bullock of the same weight, and more per kilo for a yearling immature than for a five-year-old steer.

In any development scheme involving a significant increase in output, slaughter facilities may prove a bottleneck. New abattoirs may have to be built or existing ones extended. Besides buildings, an abattoir requires investments in equipment, plant, refrigerated storage and holding grounds for the cattle waiting slaughter.

When a meat processing factory is planned, two factors especially need investigation, the location of the plant and the availability of sufficient numbers of cattle to process. In appraising a plant an estimate should be made of "the breakeven through put" of cattle required annually to secure the viability of the plant. It is the failure to achieve this level which is the main reason for the many failures of processing plants and modern abattoir complexes in developing countries, especially in Africa (18).

IMPROVING PASTORALIST SYSTEMS

The main problem in pastoral systems arises from the fact that while animals are owned by individuals, the pasture resource is owned in common. This creates difficulties when the number of animals exceeds the capacity of the grazing resource, following, for example, control of epidemic diseases and allowing greater animal survival, or when part of the rangelands are enclosed either for arable farming or for large scale ranching, or the pastoralist population grows and the size of family herds increases to provide milk for their owners.

However disastrous the consequences of overstocking are, the individual herd owner cannot see any advantage to himself in reducing his cattle numbers where land is communally grazed because others will expand their cattle numbers to fill up the void. This is a classic case of the divergence between individual and social benefits. Consequently there is a high probability that a voluntary destocking scheme will prove a failure. Even with compulsory schemes, many cattle owners simply transfer their surplus stock from the controlled area to elsewhere, increasing the pressure on land probably already overgrazed, and hastening the process of degradation.

In principle, there are three main ways by which overstocking may be dealt with:

a. destocking;
b. by extending the range resource;
c. by improving the productivity of the range resource.

Before embarking on any of these, planners should consult and seek the views of the pastoralists concerned.

Destocking

To have any lasting effect, destocking should involve a reduction in the breeder base (ie the stock of fertile heifers and cows) since the gains to pasture improvement from selling surplus males at an earlier age are rather limited (32). Further it cannot always be assumed that there are large numbers of immatures surplus to the pastoralists' requirements which can be tapped with better marketing facilities. Evidence from Uganda, Kenya, Sudan and Somalia suggests that immatures are usually a small proportion of the cattle herd in those societies where milk is a major item of diet (34). Under some circumstances calves may be killed to increase the milk available to pastoralists. Any project concerned with increasing offtake (defined as commercial sales) should

include an analysis of herd structures, in order to establish the potential offtake available, and account taken of pastoralists' attitudes towards cattle as assets for accumulating wealth. Sale of breeding stock comes hard to the pastoralist who is essentially a subsistence producer living off the milk produced by his herd and who may also wish to build up his herd as an insurance against drought and disease, as a form of saving, and as a mark of social prestige. As his land becomes progressively more limited, and as both his family numbers and his herd become more numerous, the already poor pastures get even poorer and the cows each give less milk. The pastoralist attempts to correct this by increasing cow numbers. When there is a drought, numbers plummet, but the herd composition is such (a high proportion of fertile females) that within a few years the herd is back to its former size (16). The acute and daily need of milk for the family means also that the calves, especially the bull calves, may be undernourished, which may help to explain high calf mortality rates. Because each pastoralist family needs a certain number of milk animals to provide for its subsistence needs (15), these determine a minimum herd size per family. Thus excess cattle population may in fact be associated with excess human population. To reduce the stock:human ratio may be good for the land but it may mean a deterioration, at least in the short term, in the standard of living of the pastoral community (30). In such instances, reduction in cattle numbers may only be achieved if there is simultaneously a reduction in numbers of human population throughout migration and resettlement in some other part of the country.

Given the environmental constraints of existing production systems, pastoralists will not be able to achieve major reductions in the time taken to produce finished cattle for slaughter. Hence more attention should be given to the encouragement of sales of immatures, through improving marketing and logistical facilities.

The provision of more consumer goods at markets patronised by nomads, could also provide an added incentive for selling cattle. If pastoralists could be induced to change their dietary habits and substitute purchased foodstuffs for part of their daily milk intake, then this would not only create new cash needs but would also help to raise the productivity of their livestock by releasing milk for better calf nutrition. The basic requirement, however, to increase the sales of immatures (mainly surplus males) is a growing market for them especially in the specialised fattening sectors of the beef production industry.

To encourage pastoralists to sell animals requires a positive price policy. It has been argued that with limited cash needs, the pastoralist has a perverse supply response, selling only what is necessary to purchase a given quantity of goods, thus selling fewer animals when prices are high than when they are low (31). This may be the case for individual pastoralists, with small herds, close to minimum subsistence levels. There is evidence, however, that most pastoralists require increasing quantities of goods and services from the rest of the economy and therefore respond positively to higher prices for livestock (29). Most significantly, dietary habits are changing and maize diets are beginning to be substituted for milk. The long term strategy for encouraging pastoralists to reduce the number of their stock must therefore be to foster the exchange economy, for Government to pursue a positive price policy and to provide adequate market infrastructure in terms of stock routes and facilities for animal transfer. Attempts to encourage destocking by levying taxes on the number of stock kept or charging for access to grazing land or water have not been very successful because it is usually difficult to establish cattle ownership under extended family systems and nomadism. Tax collection at veterinary centres or dips is to be avoided, whereas taxes levied at markets can be a direct disincentive to destocking.

Destocking and/or encouraging the sales of immatures can help stop the further degradation of existing rangelands but cannot of themselves do much to raise productivity nor remove the basic reason for the existence of the nomadic system - seasonal shortages of feed and water. Only when these constraints are reduced will the carrying capacity of the land and the time taken to rear a saleable steer, be improved significantly.

Extending the range resource

In some situations it may be possible to extend the rangeland resource either by siting boreholes in undergrazed dry season reserves or by eliminating a disease hazard (eg tsetse) from potential rangeland. Bush clearing can be a labour intensive, employment-creating, activity. Care is needed in the siting of boreholes so that they do not result in localised high stocking rates and overgrazing. Planners need to refer to maps (or make them if not available) showing transhumance routes, stock routes, the distribution of transmissible diseases, pasture land availability and estimated carrying capacities, water points, and existing stocking rates.

Improving rangeland productivity

A third possibility is to improve the productivity of the range resource by controlled grazing and the introduction of improved grass and legume species. To achieve this will require some sort of agreement among groups of pastoralists to follow recommended practices, eg for each herd owner to continue to own and control his cattle but belong to an association which has exclusive and permanent grazing rights on clearly defined pasture areas.* Within these areas there should be control over the number of animals to be grazed and acceptance that a particular stretch of land should be for wet season grazing, dry season grazing, burned or left fallow. End of dry season feed is likely to be an important constraint. Experience has shown that these types of scheme are not easy to put into practice, partly because it is difficult to assess the carrying capacity of rangeland (experts' estimates can vary by as much as +/- 50 per cent) and partly because of local climatic variability which makes it difficult to confine pastoralists to particular blocks of land in times of drought (21).

Group ranches

A possible initial approach is to give a small group of cattle owners the exclusive rights to a tract of natural rangeland, to which permanent water is supplied (41). This may not eliminate the need for migration in dry years, unless there is provision for supplementary feed or fodder conservation.

Such usufruct rights can provide security for investment capital loans to cover the costs of boreholes, pumps, pipes and water troughs together with the construction of cattle yards, dips and crushes and other items of fixed equipment.

Given a generous land-to-cattle ratio, sufficient grazing could be reserved for the dry season by careful herding practices. The dry grasses can both be made more palatable and more nutritious by providing urea or by other treatment, eg with caustic soda. Expert advice however is necessary before adopting such a practice.

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*Elements of this approach can be found in the tribal grazing land policy of Botswana, the group ranches of Kenya, village ranches of Shinyanga in Tanzania, the pastoral associations of Chad, the state ranches of Niger, the grazing associations of Somalia and the herdsmens' associations of the Central African Republic.

If successful such communal ranches could evolve into a more sophisticated system in which the land is enclosed into paddocks and water provided to each paddock. Since it is illogical to spend large capital sums on fencing open bushland with a low stock carrying capacity, additional sums would have to be budgeted for land clearance. Once enclosed, rotational grazing can be practised, and even the cultivation of suitable forage crops for dry season feeding can be tried. Such fenced ranches are at present confined to state and commercial run enterprises.*

The sort of progression sketched above requires the cooperation of the people concerned which partly depends on whether their needs and aspirations have been taken into account by the planners at both the project formulation and implementation stages. A complicating factor is that nomadic societies are not egalitarian and the numbers of cattle owned by individual families can vary widely. The larger herd owner may be unwilling to join a communal ranch where he is given an equal vote on the management committee with a small herd owner. All these attitudes are worth investigating before any major communal ranching project is set up. Considerable thought should also be given to the institutional and managerial aspects of such schemes (23).

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*Fencing should not be regarded as a sine qua non of ranching, as it has high initial and maintenance costs. Its function can be carried out by herdsmen, who will also keep the ranch manager informed of cattle behaviour and help to protect cattle against predators.

IMPROVING SMALLHOLDER SYSTEMS

Smallholder beef production in the more humid parts of the tropics is associated with peasant arable farming systems in which beef production per se is a relatively minor enterprise, confined in practice to fattening only a few cattle at the same time. Yet because most cattle for slaughter emerge from the very large numbers of holdings involved (see Figure 1) and because of the availability of feed in these more humid zones, it is commonly argued that these systems offer a great potential for an increase in beef production (45).

To expand output it is necessary to increase the profitability of beef cattle on these farms which already keep them, so encouraging others to introduce a beef fattening enterprise and providing incentives for existing producers to fatten an extra beast or two.

Beef production in such systems is based on the use of resources which have relatively low opportunity costs - family labour and crop residues. Where labour is no constraint, cattle can be herded individually or even tethered. Cattle can also be green soiled (or zero grazed), that is, housed in yards and/or sheds and fed from troughs to which the feeds are brought in from the field. In this way, wastage from treading and fouling can be reduced. In such ways the maximum use is made of whatever feeds are available.

Because of the length of time taken to breed, rear and finish an animal for beef, smallholder specialist beef production systems tend to concentrate on one part of this cycle only; the finishing process. For this to be profitable there must be sufficient margin between the prices paid for immature stock and received for fat stock to cover the costs incurred in the actual finishing process. Hence the importance not only of the least-cost food mix,* but also of cattle prices and the inherent risks of losses from diseases and deaths. An immature steer is a very "lumpy input" for a peasant farmer. The purchase price represents a major cash outlay and the death of an animal before sale could be a financial disaster to its owner; hence the importance of a reliable source of immatures and adequate animal health control measures, together with credit and insurance facilities linked to extension. Holding ranches for "backgrounding" steers until they have reached the fattening stage may be an essential part of the system.

*For the smallholder sector, such calculations should be carried out by the relevant professional staff of the Ministry of Agriculture and the results made available to extension workers for dissemination to farmers. Unit costs should be revised regularly.

One possible approach to this problem is to link the supply of immatures to a credit institution, which could inspect the animals before sale to smallholders and build an insurance component into the loan repayments. Another alternative is to encourage the practice of agisting cattle; keeping cattle belonging to other people rather than owning them directly. Agistment would not only spread capital risks and reduce capital outlays but also help resolve the problems of procuring immatures and selling fatstock. Where such practices do not exist, some consideration could usefully be given to the possibilities of introducing them either by the encouragement of the private sector or by the establishment of cooperatives or parastatal organisations.

RANCH IMPROVEMENT

Commercial ranches are distinct from pastoral systems in that:-

i. land is privately owned and its boundaries are defined, usually by fences, sometimes by beacons or tracks;

ii. the main objective is long-term profitability in terms of the rate of return on capital invested in stock, land and associated fixed assets.

With a fixed land resource, production is usually measured in terms of annual output per unit of land, although output per animal is still an important consideration. Cattle become a means of converting the limited range resource into a stream of cash flows from the sale of animals. The productivity of that resource is itself determined by the type and number of animals carried and how they are distributed over time and space, ie by grazing management.

Initial investment decisions concern target stocking rates, which are in turn determined by the estimated carrying capacity of the rangeland, year-to-year variability in rainfall, and the potential for pasture improvement. The extent of investment in water provision and fencing will also influence and be determined by target stocking rates.

Given a target stocking rate (in terms of animal units) the type of ranching enterprise will be influenced by its location within the breeding - rearing - fattening continuum. While the most profitable livestock operation for higher potential land is the fattening of large frame steers bought in from drier areas, the need to maintain stocking rates in the face of uncertain supplies of immatures may necessitate that fattening operations be combined with some breeding. On the other hand, because of year-to-year variability in rainfall, specialist breeding ranches may limit the size of their permanent breeding herd, and aim to attain full stocking by buying in or retaining a varying number of immature cattle according to market and weather circumstances.

Once the type of beef operation has been decided upon, attention focuses on herd productivity coefficients and how these may be influenced by management and

nutritional measures. For the breeding herd, the emphasis is on fecundity and its components: age at first calving, calving intervals, calf survival rates. For the fattening herd, emphasis is on rates of liveweight gain in relation to the costs of feed.

Supplementary feeding of breeding livestock with groundnut or cottonseed cake during the dry season has been shown to have significant effects on herd reproductivity, and hence on long term herd growth, in Central Africa (42). In South America (2) mineral supplementation alone has been shown to have important effects on calving and weaning rates. In considering dry season supplementary feeding of immatures account needs to be taken of possibilities of compensatory growth in relation to the costs of alternative feeds at different times of the year. Biological efficiency may differ from economic efficiency because of these considerations. However it should be noted that animals, especially immatures, which are malnourished are very susceptible to disease. Too meagre a diet may cause serious economic loss. A further aspect of herd management is control over breeding so that the critical periods of the reproductive cycle (conception, calving and lactation) are synchronised with the most favourable season of the year, when feed sources are cheapest.

Given a satisfactory health status of the herd attained by sufficient provision of veterinary services, a principal concern of ranch management is grazing control, since natural pasture is the main source of cheap feed. There are three areas of concern: rotational grazing, the introduction of superior grasses and/or legumes for pasture improvement, and conservation. Deferred block rotational grazing is an alternative to continuous or seasonal grazing which allows blocks rest periods, with successive grazings in any block deferred so that they fall at different times of the year. The introduction of new grass/legume species by reseeding or overseeding should follow research and small-scale experimentation, and requires skilled management if it is to succeed. The need for reserve grazing has to be assessed in each case in relation to rainfall reliability and the intensity at which the land is usually stocked. Similarly, the question of conserving fodder as standing hay or cutting it at an earlier stage of growth when its nutritive value is higher depends very much on local economic and ecological circumstances.

In some areas, small patches of land may have enough moisture to permit the growth of sugar cane. This plant increases in energy value as "standing hay", which other

grasses do not. Although sugar cane alone will provide only energy, and thus a far from balanced diet, animals may thus be kept alive until new grass springs up. There is voluminous literature and much active research in the use of sugar cane and agricultural by-products in animal nutrition (11).

Under more intensive ranching the grazing area is usually subdivided by fences into paddocks. The purpose of this subdivision is to allow the separation of the stock into different groups. This permits control of breeding seasons, mating of cows to specific selected bulls, artificial weaning of calves and prevention of premature mating of young female calves. Other benefits are prevention of overgrazing, preservation of grazing for dry season feeding and the possibility of controlling stocking rates in order to improve the quality and productivity of the grazing resource enclosed. Connected with the fencing layout should be a system of water reticulation which reduces the need for animals to walk long distances for water and prevents overgrazing around watering points.

Once the basic costs of fencing and water reticulation have been incurred the ranch manager can chose from a wide variety of techniques which will improve turnover and offtake. As well as improved levels of disease control, which are likely to be vital to economic viability, productivity can be improved through mineral, protein and energy supplementation at strategic points in the beef cow reproductive cycle, cross breeding with exotic stock and the possible use of growth promotors. Central to further ranch improvement however is the introduction of a beef cattle recording system as a management tool. To be really effective this should include the weighing of animals at periodic intervals as a method of objectively assessing animal performance. Whilst this is essential for schemes involving genetic improvement the data can also be used to evaluate the various other forms of improvement mentioned above. Computer systems are available for use with large ranching enterprises (see (33)). For the smaller ranch owner a simpler system will no doubt suffice.

Connected with accurate data collecting is the need for adequate stock handling facilities where animals can be ear tagged and/or branded, sorted into different groups, weighed and loaded into trucks where necessary. Such facilities are likely to be associated with facilities for dipping and/or spraying cattle and will be used for veterinary inspections. The correct siting of such facilities is important in order to ensure ease of management of the ranching operations.

FEEDLOTS

While some knowledge of the concept of least-cost food mix is desirable for extension workers concerned with smallholder beef production, it is vital to managers of large scale feedlots where possibly thousands of head of cattle a year are being fattened.

In planning such an enterprise the degree of expertise reached and the sizes of the investment and working capitals involved, would probably justify the employment of consultants both in the initial appraisal and in the implementation stages. In the interests of economic efficiency feedlots should be sited close to the source of feed and slaughtering facilities. Other points for consideration include, at the planning stages, the sources of immature cattle for feeding, their likely purchase costs at arrival in the feedlot, the likely length of the fattening period together with possible initial and final liveweights. Health control measures, the availability of water, and methods for manure and urine disposal should not be forgotten. Markets and prices for the finished products are important but perhaps the most vital factor is the availability of experienced managerial and technical staff. Due consideration must also be given to cash flows, especially the timing of major purchases and sales of cattle.

The profitability of beef fattening operations depends critically on the following factors:

i. the purchase price per kg liveweight of immature stock;
ii. the selling price of fat stock (per kg liveweight);
iii. the rate of daily liveweight gain;
iv. the price of feedstuffs.

These relationships are well illustrated in Table 1 which shows how profit margins depend on the ratio between the feed/beef price and the gap between the immature steer price and the fat steer price (per kg liveweight).

In this example, rapid rates of liveweight gain are postulated based on a high energy diet of maize. In most developing countries (unlike the USA and Europe) fattening beef animals on maize is unlikely to be profitable because maize prices will most likely be set at import parity levels (world prices plus transport and

handling costs) while beef prices will be set at export parity prices (world prices less transport and handling costs). Thus the difference between the costs of feed per kg and the price of beef per kg will be relatively small (43). In developing countries, fattening operations will normally be profitable only if forage crops and crop by-products constitute the bulk of the diet.

TABLE 1 PROFIT MARGINS IN BEEF FATTENING*

Price Ratio Maize: Beef	Immature Steer Price as % of Fat Steer Price				
	60	70	80	90	100
	Profit as % of Gross Output				
1 : 10	23	17	8	0	-7
1 : 9	21	15	6	-2	-9
1 : 8	18	12	3	-4	-12
1 : 7	15	9	0	-7	-15
1 : 6	11	5	-4	-11	-19
1 : 5	5	1	-10	-17	-25
1 : 4	-4	-10	-19	-26	-34

*Basic assumptions are: High energy ration, conversion rate 8 : 1, weight gain 1 kg per day, immature steers weigh 300 kg, fat steers 400 kg.

Source: after W Schaefer-Kehnert (39)

Export markets

In nearly all developing countries, demand for beef products is growing as populations and incomes rise. For some countries (eg Botswana, Ethiopia, Sudan, Uruguay, Argentina) beef exports make significant contributions to foreign exchange earnings; in others, the country's foreign exchange is spent in part on purchasing beef or animals on the hoof, eg Nigeria, the Philippines. In the former case, it is appropriate to value additional domestic production of beef at the price it will receive in export markets (the export parity price); in the latter, at what it would cost to import (the import parity price).

Beef may be exported in several forms: as fresh meat, chilled meat, frozen carcases, canned meat, or on the hoof. The world market for meat products is divided by health regulations imposed by importing countries into a higher price and a lower price market. For entry into the higher price market (mainly for frozen carcase meat) the producing country must satisfy the importing country that it is free from infectious animal diseases (particularly foot and mouth) and that its abattoirs achieve certain sanitary standards. Some importing countries impose tariff barriers against some exporting countries eg the EEC imposes tariffs and quantitative restrictions against Argentina's beef industry.

Possibilities of air freighting prime fresh cuts of meat to international tourist centres and to oil-rich Arab States exist on a limited scale but competition is considerable and for Arab markets, religious slaughter requirements have to be met.

One way to get round health regulations, is to export manufactured meat which has already been cooked and so sterilised. Demand exists for a variety of canned products and also for processed cooked meat which can be further manufactured in the importing country - for example pickled beef exported in barrels. Such meat is imported into the United Kingdom and used in the manufacture of products like luncheon meat and meat loaves - blended with cereals and then canned either in small tins for normal retail sale or in large tins for catering or for resale as sliced meats. In developed countries, there is a growing demand for "convenience foods" not only for domestic use but also for institutional catering. These are foods already partly prepared. The use of such foods reduces the amount of work

done in a kitchen by transferring it to a factory which could well be sited in a developing country provided that very stringent health regulations are met.

Another way is to try to fulfil the health regulations of an importing country. These usually require that the animal should come from areas free of listed diseases and be slaughtered under hygienic conditions. The costs and benefits of such a policy need careful examination for particular country situations.

In considering the prospects of a new export market or expanding in an existing export market, it is advisable to commission a special survey to cover such topics as barriers to entry, trade channels for beef marketing and future demand, supply and prices. Such a survey could be undertaken by a firm of marketing consultants, the Tropical Products Institute of the ODA, or the International Trade Centre (27).

World market prices in relation to domestic prices

While world demand for meat is growing at about 2.5 per cent per year, prices historically have shown a cyclical pattern of about six to seven years reflecting the time lags in adjusting supply to a new price situation. In the short term, it is difficult to increase the output of beef since the number of animals ready for slaughter is given. To some extent supply can respond in the short term by additional feeding of fat animals or early slaughter of younger stock, but these effects may be offset by the tendency for producers to hold back stock from slaughter in the expectation that prices will rise even further (28). In the longer term, supply responds because more breeding females are retained in the beef herd, or more beef calves are born as a result of dairy herds being crossed with beef bulls. The new beef animals will come onto the market in developed countries where liveweight gains are rapid under intensive production systems some two to three years after the initial price stimulus, which along with variation in the price of food/feed grains helps to explain the periodicity of the beef cycle (20).

During the past ten years the world beef economy has been particularly unstable. A period of rapidly rising demand during the late 1960s culminated in a sharp increase in international prices in 1972/73, and was followed by a sudden collapse in 1974/75, with a recovery in recent years. The peak price period in the early 1970s reflected rapid economic growth in major consuming countries on the demand side and was accompanied by a synchronization of the cyclical downswing among major exporting and importing countries on the supply side.

World cattle numbers are projected by FAO to increase from 1280 million in 1972-74 to 1460 million in 1985 (22). Although developing countries would account for more than two-thirds of the projected 1985 world total, their share of world beef output would remain as low as one-third, reflecting lower offtake rates and carcase weights (see Table 2a). Productivity gains are projected to contribute more to the increase in beef production in developing countries than expansion of stock numbers.

TABLE 2a CATTLE NUMBERS, OFFTAKE RATES AND SLAUGHTER WEIGHTS

	Actual 1972-74 Average			1985 Projected		
	Cattle Numbers (million)	Offtake Rate (per cent)	Carcase Weight (kg)	Cattle Numbers (million)	Offtake Rate (per cent)	Carcase Weight (kg)
World	1281	16.9	189	1458	18.2	203
Developing Countries	856	9.6	157	980	11.1	164
Latin America	243	14.4	193	304	16.5	193
Argentina	54	18.5	218	69	24.1	199
Brazil	86	12.8	195	112	13.0	200
Africa	124	11.0	124	138	12.1	137
Near East	46	18.3	104	55	18.6	119
Far East	340	3.1	124	372	3.7	131
Asian Centrally Planned Economies	103	13.7	155	109	16.2	164
Developed Countries	425	31.8	208	478	32.7	230
USA	122	31.0	269	136	34.0	282
Western Europe	100	34.2	210	106	35.5	225
EEC	78	33.3	219	83	34.3	233
USSR	105	33.6	158	120	33.0	189
Eastern Europe	32	32.5	177	37	31.1	205

Source: FAO (22)

TABLE 2b BEEF AND VEAL : ACTUAL AND PROJECTED PRODUCTION

(thousand metric tons)

	1962-64 average	1975-77 average	Projected 1985
World	31,051	46,646	53,720
Developing Countries	10,693	14,239	17,860
Latin America	5,759	7,764	9,620
Argentina	2,425	2,693	3,330
Brazil	1,371	2,227	2,910
Colombia	373	527	610
Mexico	439	573	720
Uruguay	282	360	390
Africa	1,389	1,807	2,270
Algeria	18	28	40
Ethiopia	220	210	250
Nigeria	138	171	210
Southern Africa	104	208	310
Near East	606	943	1,230
Iran	62	114	150
Sudan	90	227	330
Turkey	182	231	290
Far East	933	1,417	1,810
China	1,833	2,089	2,660
Developed Countries	20,358	32,407	35,860

Source: FAO (22)

World demand for beef is projected to increase at 2.4 per cent per year, which is somewhat less than the 3.0 per cent growth in consumption over the past decade (see Table 3). Latin American countries will continue to have the highest beef consumption among the developing countries, while per caput consumption growth rates are expected to be higher in countries in the Near East region and some of the richer developing countries. Beef consumption will remain low in Africa and in the Far East.

World trade in beef, veal and live cattle is projected to increase by a sixth from 1972-74 to 1985 (see Table 4). A sizeable proportion will be intra-EEC trade. Australia, Argentina, New Zealand and Ireland will remain the leading exporters. Uruguay, Sudan and Eastern European countries will increase their beef exports, whereas Brazil's exports are expected to decline and those of Central America to level off. The USA and Japan are projected to continue to have the biggest net import requirements, while Korea, Canada, Spain, Greece and Israel will also buy more. For the Near East, sizeable increases in beef imports are expected, while other OPEC members, notably Nigeria, Indonesia and Venezucla are projected to become important buyers.

TABLE 3 BEEF AND VEAL : CONSUMPTION AND PROJECTED DEMAND

	Total consumption		Per Caput kg/year	
	1972-74	1985	1972-74	1985
	(thousand metric tons)			
World	40,814	53,630	10.7	11.3
Developing Countries	11,837	17,630	4.4	5.0
Latin America	5,861	8,740	19.1	20.6
Africa	1,517	2,300	4.8	5.2
Near East	912	1,570	5.0	6.2
Far East	1,371	2,040	1.3	1.5
China	1,955	2,660	2.4	2.7
Developed Countries	28,977	36,010	26.3	29.7
North America	12,058	15,420	51.9	58.8
EEC	6,327	6,810	24.7	26.0
E Europe and USSR	7,441	9,550	20.8	24.0
Japan	374	560	3.5	4.6

Source: FAO (22)

TABLE 4 BEEF AND VEAL : ACTUAL AND PROJECTED EXPORTS AND IMPORTS*

	Net Exports		Net Imports	
	Actual 1972-74	Projected 1985	Actual 1972-74	Projected 1985
	(thousand metric tons)			
World	3,522	4,090	3,299	4,000
Developing Countries	1,433	1,650	413	1,420
Latin America	1,066	1,240	154	360
Africa	309	300	121	350
Near East	13	70	55	410
Far East	20	20	66	250
Developed Countries	2,079	2,440	2,885	2,590
North America	0	0	911	1,120
EEC	631	810	1,259	900
E Europe and USSR	304	380	366	110
Oceania	1,021	1,160	0	0
Japan	0	0	80	140

*Net trade of beef at the country level, including intra-EEC trade

Source: FAO (22)

The prices in the world beef market will influence to a greater or lesser extent the internal prices in a developing country, depending on the price policies of Government and the openness of that country to trade. The price policies of Government are likely to reflect the political strength of cattle producers relative to other groups in the national economy. In countries like Botswana internal prices reflect export parity closely, while in Kenya internal prices of meat and hence producer prices are held below export parity levels in the interests of consumers: there is an implicit subsidy from beef producers to domestic consumers. In Latin America, a major political struggle revolves around beef prices to consumers in urban areas. In order to minimise political pressures from powerful urban groups, governments have resorted to a host of measures to keep meat prices down. These include price controls, prohibition of exports, dual exchange rates, subsidies to ranchers, and even imports of meat.

In projecting internal economic prices of beef or beef animals for a project in a country where domestic prices are insulated to some extent by Government pricing policies, reference may be made to the price forecasts of the World Bank (47). These refer to average prices for Argentine frozen beef to the EEC and Australian oxen wholesale in Brisbane. Such prices need to be related back to prices at point of export or import in the developing country concerned. Usually it is convenient to make the assumption of proportionality between world prices and the relevant "border" price, so that if the world price is projected to increase by 50 per cent in real terms over the next years, the border price is increased by the same amount. A more careful analysis would deduct transport and handling costs from the European market to arrive at a border price and then take explicit account of projected increases in transport costs in arriving at a price forecast for some future year. Most appraisals do not go to this length because the uncertainties inherent in the price forecasts do not warrant such spurious attempts at accuracy. Instead, the project's internal rate of return may be subject to price sensitivity tests. Given a border price for carcase beef, there is a need to convert this into an internal retail price for beef, a wholesale price, and back through the slaughter house to a price per kg of liveweight for different weights and grades of animals. This in turn translates back through internal markets for live animals to a price for immatures. While it may be feasible in principle to calculate this price by means of allowances for transport costs and traders margins, the best way of ensuring that livestock producers receive a fair price is to see that there is adequate competition at all tiers of the marketing chain and that there are facilities for weighing animals.

In some developing countries the State, for political and social welfare reasons, has intervened in the market by establishing maximum retail prices, often according to grades and cuts. Such prices in periods of inflation have cut down the incentives to producers while encouraging domestic consumption - Brazil and Kenya provide examples. Holding retail prices at artificially low levels in the interests of consumers is likely to result in a scarcity of meat in urban markets, and to overstocking in the rangelands.

Payment by grade to producers is again a practice which requires scrutiny. Too often the grading system is more applicable to a developed rather than a developing country, with too great a price premium for quality meat which, in the absence of export markets, can be difficult to sell at a suitable price.

Fiscal policies also have effects on supplies. For example poll taxes on cattle numbers may be both a direct disincentive to producers and also lead them to evade the use of such improvements as health regulations, stock routes and auction markets which are designed to increase productivity. Producers are wary because of their fear of being caught by tax collectors. Taxes on imported inputs such as fertilisers, drugs and other requirements, add to costs. Land taxes can discriminate against extensive beef production systems. The problem of fiscal policies is partly one of balancing costs of collection against revenues together with the effects of tax incidence in relation to incentives. Poll taxes can in principle effectively discourage overstocking while land taxes should lead to the more intensive use of land.

The list of possible side effects of government policy, including the implementation of major projects, is obviously long and to cope with such complications it is necessary to have in-depth knowledge of the market which is constantly up-dated by effective monitoring of the position.

Quality and grades

Beef is not only a product of heterogeneous systems but is a heterogeneous product in itself. Carcases yield not only edible beef but a variety of by-products such as hides, bones, blood, fat and inedible offal. Appendix 3 gives some figures relating to carcase composition. Where an investment project such as a meat processing factory is concerned, beef by-products will be produced in quantity, so it would be desirable to assess the market demand for these products, since the financial viability of the whole project may depend on the effective marketing of all these miscellaneous items. The discussion here is confined to edible meat.

Edible meat is again a heterogeneous product, differing in quality not only according to the age, finish and breed type of the animal but also according to cut - for example the prime cuts from the hindquarters as opposed to less highly prized meat from the forequarters.

In developing countries the mass market will want cheap rather than quality beef. A small luxury market will probably exist for high quality beef - the local élite, expatriates and tourists. Beef processing industries also rely on the lower qualities but often a very limited amount of higher quality meat has to be included with the other grades in the manufacture of certain products.

Price and income elasticities of demand

Formally, the quantity of beef demanded is a function of the price of beef, consumers' incomes, the prices of alternative products, and population. There are few empirical estimates of price elasticity of demand for beef for developing countries, but one would expect in most countries a fairly high elasticity, ie greater than 1 in absolute value, because beef is for most consumers a luxury with many close substitutes eg pork, fish, lamb. The implication of a relatively high price elasticity of internal demand is that if internal markets are insulated from world markets, internal supply shifts occasioned, say, by a drought year, will not result in very large domestic price fluctuations.

Most developing countries are price takers in world markets. That is, they are unable to influence the level of prices by changing the quantity of beef they export.

Demand projections are usually based upon projected increases in incomes and population. FAO's Trade and Commodity Division has well developed methods for projecting demand (19) and an application of such procedures to a Philippine example is given in Appendix 4.

The basic steps

The usual sequence followed in the economic or financial appraisal of a beef investment project is as follows:

(i) identify the principal project components;

(ii) assign costs to each component and distribute costs over time;

(iii) make a preliminary check that the monetary benefits of each project component exceed the monetary costs;

(iv) assess the likely impact of project components (separately if possible) on herd productivity, typically by relating them to improvement over time in one or more of the technical coefficients (population, nutrition or productivity);

(v) construct a herd model based upon available data and project output in the "with" and "without" project situations, according to the improvements in coefficients indicated under(iv);

(vi) convert physical output over time to monetary values by applying appropriate prices;

(vii) having quantified the benefits and costs over time by steps (ii) and (vi), calculate annual income and expenditure streams and obtain net cash flows which may be discounted to obtain the net present value, the benefit/cost ratio or the internal rate of return, using standard procedures;

(viii) having obtained a financial rate of return for the project, calculate an economic rate of return by adjusting market prices and input costs to allow for market imperfections, transfer payments within the economy and artificially high or low exchange rates;

(ix) subject both financial and economic rates of return to sensitivity tests and risk analysis;

(x) consider the indirect costs and benefits of the investment, paying particular attention to income distribution, environmental and employment effects.

In some large projects it may be necessary to calculate cash flows and financial rates of return under step (vii) for more than one entity, eg a project may comprise a ranch or feedlot via a parastatal marketing organization. The cash flows for the breeding and rearing unit, the fattening unit, and the marketing organization would need to be considered separately. The economic appraisal would then be based on the overall costs of investment in each entity in relation to the incremental output arising at the end of the production process, in this case, the additional output over time of fat stock for slaughter.

Identifying programme and project components

In designing programmes and identifying the principal components, planners should check through the following list of points:

(i) Are the objectives clearly stated and are they a priori attainable?

(ii) Is the design and are the means chosen appropriate to achievement?

(iii) Is the specified Ministry/institution the most appropriate executing agency - if not whom?

(iv) Are the technical coefficients reasonable or optimistic, and is the basic information on cattle numbers and offtake rates reliable?

(v) Have all the costs been realistically budgeted for and is there a satisfactory relationship between costs and benefits?

(vi) Is the project competitive in comparison with comparable projects?

(vii) Is the timing and sequence right? If not, is there sufficient flexibility to adjust - critical path analysis - cut off point?

(viii) Has the maximum economy been exercised in the use of foreign exchange?

(ix) Has the maximum economy been exercised in the use of scarce managerial, professional and technical skills - especially expatriate staff?

(x) Are there people with the will to see the project through?

(xi) What is the future of the project - will it become really self-supporting and then will it provide any spin-offs?

(xii) Does its implementation or future depend upon action by some other Ministry/agency? Is this dependency accepted and catered for?

(xiii) Is there provision for adequate evaluation (on-going for management and ex-post for lessons to be learned)?

(xiv) If all the answers are affirmative, get an independent appraisal!

(xv) If the project is designed to bring services to the people, will it in fact be regarded as satisfactory by them?

While this part of the manual is principally concerned with the appraisal of "projects", it should be recalled that livestock planners are often concerned with "programmes" whose benefits may not be sufficiently quantifiable to lend themselves to conventional cost/benefit analysis. Thus strengthening supporting services to livestock producers in such fields as extension, veterinary facilities, training and research are in most cases additions to an existing programme and although the incremental cost may be clear, the

incremental benefit is hard to dissociate from the prior investment, even when it can be quantified. However the underlying thinking concerning the sequential improvement of systems discussed in the first part of the manual, and the general approach of project appraisal, should be kept in mind in appraising programmes.

Costing project activities

Capital items can be divided into investment and working capital requirements. Capital costs can be financed through the banking system on a long term credit basis, or be contributed by the entrepreneurs who are involved in the project. The usual arrangement is for the major share of the capital requirements to be borrowed, often by special credits made available through the banking system from bilateral or multilateral aid agencies.

Investment capital is concerned with the costs of establishing the project. It includes such items as:

a. fixed equipment (buildings, roads, fences, dips and crushes, water boreholes, pumps, pipes and troughs, weighbridges);
b. moveable equipment (vehicles and machinery);
c. foundation livestock.

Working capital or recurrent expenses are concerned with the costs of running the project. These include:

a. Salaries and wages of managerial staff and skilled and unskilled labour;
b. costs of purchased feed and water;
c. veterinary services;
d. cattle purchases, ie breeding cattle replacements, immatures for finishing;
e. feed and energy costs for operating plant, machinery and vehicles.

It is normal practice to subdivide costs into foreign exchange and local cost components, particularly if the project is to be funded by external agencies. To avoid double counting, care should be exercised in allocating

costs between different headings. For example, only the costs of purchased feed and any charges for water brought into the project should be listed separately, as in most instances the bulk of feed and water costs will be subsumed under other heads.

Where shadow pricing is done, labour costs are a major concern. The usual practice is to deflate the market prices for skilled and unskilled labour on the grounds that going wage rates overstate opportunity costs in developing countries plagued with unemployment or underemployment. In fact it is often argued that unskilled labour should either be charged at a nominal cost or not be charged at all, nor should an allowance be made for the family labour of small producers participating in a new project. Much depends on the availability of labour relative to other factors of production, eg land and seasonal peaks of labour demand in cultivation.

Investment capital input can either come in as a "lump" in the first year of the appraisal or be spread over the years. It is shown as a cash inflow while interest and debt repayments are shown as cash outflows in the financial analysis.

As loans have interest and repayment liabilities, it is important to assess the point of time when the project should be generating sufficient income streams to be self-financing.

Interest charges are entered at going rates in financial cost/benefit analysis (based on market prices). In an "economic" cost/benefit analysis (based on the use of shadow prices) interest charges are usually excluded on the grounds that they represent transfer payments within the economy, unless they relate to international loans.

Depreciation, if included, is usually charged in the last year of the projection as the difference between the initial values of fixed and moveable equipment and the residual values at the end of the last year of the appraisal. This is done because a fixed annual depreciation charge does not represent an actual yearly cash outflow.

Indirect costs are not normally included in a financial appraisal but selected items could be included in an economic appraisal. Possible indirect costs with a ranching project might be an allowance for the costs of the additional

extension and supervisory staff required and an allowance for the loss of the output from the land before development - for example, income from the sale of nomadic cattle and other livestock, charcoal and wood.

Estimating population coefficients

Technical coefficients determine the physical input/output ratios. They cover such concepts as birth and death rates and carrying capacity of land. Such coefficients often include economically crucial determinants (sensitive variables). Hence the values assumed in the projection should be as realistic as possible. Data used should be based on local experience in the field and never on results obtained under the more favourable conditions of a research station (17). Data should also be cross-checked with the results obtained in other projects with similar conditions (results, rather than the coefficients used in the original appraisal).

The normal practice in making an appraisal is to assume that the technical coefficients improve over the time-span of the project. Care is needed that these are not too optimistic, given the risks and uncertainties associated with livestock production.

A general caveat is: not to equate a high level of technology with high economic performance. The costs of obtaining the technical coefficients associated with high levels of technology may be too great even if feasible, given the managerial and technical resources of a developing country.

A critical step in project appraisal is assessment of the impact of the project components on herd productivity. In most situations this necessitates initial estimation of the existing herd coefficients which determine herd output in the "without project" situation. Information is needed on herd structure - the age and sex composition of the herd - and the herd population parameters, including:

i. the ratio of males to females;
ii. calving rates;
iii. weaning rates;
iv. mortality rates at different ages;
v. ages at sexual maturity;
vi. ages of immature cattle at sale for fattening;

vii. ages of finished animals at slaughter;

viii. ages of surplus breeding stock at culling.

Constructing herd models

Typically, complete information on these parameters is lacking. It is therefore necessary to construct a herd model from whatever information is available (both quantitative and qualitative) and simulate herd output, adjusting technical coefficients until there is consistency between observed offtake rates and herd structure. For example, information may be available on the age and sex composition of the herd and numbers of animals slaughtered. By choosing likely initial values for age of first calving, weaning rates etc, suggested by local specialists or stockmen, an approximation of the herd structure which is consistent with observed offtake rates can be obtained by iteration (25, 34). Caution is needed with this approach as more than one "solution" is possible.

Having arrived at a steady-state herd model, the impact of the project components needs to be assessed. Projects which incorporate health and nutrition improvements can be expected to have favourable effects on calving intervals and calf survival rates, resulting in higher weaning rates. There may also be a reduction in the age at which heifers produce their first calf and a lengthening of the productive life of breeding stock resulting in more calves produced per cow. These improvements have to be quantified and the rate at which they diffuse through the herd assessed. It is at this stage that project appraisal can easily err on the side of optimism. An annual increment in calf weaning rates from .50 to .60 over 10 years for a large herd may seem modest to the casual observer, but this is the sort of technical assumption which permits a project to achieve a satisfactory internal rate of return and become eligible for international financing.

Benefits accruing from investments in infrastructure and supporting services are difficult to identify and quantify. One approach is to take the cash revenues resulting from fees collected for their use and treat these as income streams accruing to the investment, but often no fee is charged. A better approach is to quantify the extra production thought likely to accrue from the new investment. For example, a stock route should cut down losses of animals in transit and improve their condition on arrival, by reducing weight losses. Veterinary improvements should reduce death rates, while improvements in the carrying

capacity of rangelands might increase "offtake rates". Estimates of the increased output resulting from the provision of services could possibly be based on comparisons between "progressive" producers and those operating at lower levels of technical performance, and checked with the annual costs of the new investment to see whether these are likely to exceed the estimated values of the expected benefits.

Experience shows that there is a time-lag between the introduction of an improved practice and its adoption by the great majority of producers. The planner has therefore to estimate the annual rate of adoption of an innovation in order to quantify the benefits from investment in supporting services.

Most projects affecting pastoralists include a veterinary component because it is legitimate to expect that improvements in animal health will have immediate effects on herd coefficients and lead to high internal rates of return. As earlier discussion has shown, it is not always in the longer term strategic interest to increase animal numbers when overgrazing is a problem, but attention should first be focussed on increasing offtake rates and improving or extending the rangeland resource. Project design may therefore be adversely affected by the expediency of demonstrating a high internal rate of return through initial veterinary inputs. However, veterinary inputs may be needed to win the confidence of cattle owners in the project goals (38). Excessive optimism may occur also regarding the rate at which pastoralists will increase offtake rates and/or take measures to improve the productivity of the rangeland resource, so that well-intentioned projects may exacerbate an overgrazing situation.

Other technical coefficients

In this connection, one is concerned with a second set of coefficients to do with nutrition. These include:

i. the carrying capacity of rangeland, particularly during the dry season, and in dry years (for pastoral systems);
ii. forage crop yields, crop by-product availability, and nutritive values (for more intensive systems);
iii. liveweight gains, especially for animals being intensively fattened for meat production;

iv. water requirements and the length of time an animal can go without water;

v. animal liveweights which determine feed and water requirements.

Estimation of the carrying capacity of rangeland is a critical determinant of successful project planning and one which is subject to considerable difficulty of assessment. For one project in West Africa, experts' estimates ranged from 3 hectares to 15 hectares per livestock unit. Clearly project design and strategy is critically affected by this assessment, not least with respect to investment in additional boreholes in dry season grazing areas.

A third category of coefficients concerns "productivity":

i. annual offtake rates especially for pastoralists;

ii. carcase dressed weights, killing-out percentages, and methods of grading animals slaughtered at different ages.

Predicting changes in selling behaviour of pastoralists in response to new market incentives or opportunities is difficult. Thus a project objective may be to encourage pastoralists to sell surplus male stock as yearlings for fattening on smallholder farms or feedlots, instead of holding them on the range until they are five or six years old. Assessment of the feasibility of this happening is likely to require careful socio-economic research for a particular situation. In NW Mexico the removal of young male calves from the range has been shown to be essential. The range will then support cow and calf but not a grazing bullock.

Knowledge of killing-out percentages can be obtained from slaughter houses. This information is necessary to convert numbers of animals coming forward for slaughter into tons of meat available for consumption.

Relating benefits to costs

Once information on these coefficients has been assembled, either from published quantitative data, experts' judgements, commissioned socio-economic research, or other sources, the planner is in a position to project herd growth and offtake rates for the "with" and "without" project situations, and thereby derive an incremental benefit stream.

In livestock projects, part of the annual output may be reinvested in the scheme, especially in the earlier years when livestock numbers are being built up. Normally these changes are catered for by crediting or debiting the final year with a sum representing the difference between the closing valuation of the livestock at the end of the projection period and the valuation at the beginning.

Direct benefits and costs are tangible concepts, stemming from the values of the physical inputs into the project and the resultant physical outputs. They should be easily identified and relatively easy to quantify. Indirect benefits and costs are a much more difficult matter, both as regards identification and quantification. Indirect costs cover such aspects as the loss of grazing by nomads when land is enclosed for ranching, and indirect benefits cover the demonstration effect of a successful project and the extra incomes and employment generated through the whole economy by the increased spending from those working in the beef industry.

With the refinements in the basic cost/benefit approach, the appraiser is faced with a growing complexity of methods, whose full employment could well constitute an uneconomic use of scarce professional time in a developing country. Consequently the appraiser should normally confine himself to the basic cost/benefit analysis concerned with direct costs and benefits value at market prices. A sensitivity analysis to identify the most important variables should also be made. Where the market price of a sensitive variable is thought to be distorted, then the use of a shadow price for that variable could be considered. Indirect costs and benefits would normally be limited to income distribution and foreign exchange effects except in an appraisal of the results of a major investment in infrastructure and services. Risk analysis (which requires access to a computer and the necessary programmes) should be confined to situations where the degree of risk associated with the project is thought to be high (eg major agricultural and livestock developments on rangelands in semi-arid areas).

The advice given here is to keep the method as simple as possible and concentrate on the identification and quantification of the direct benefits and costs in production investment projects, while with infrastructural and service projects including indirect benefits as well.

A very common pitfall in production projects is to take too optimistic a view of future performance especially as regards technical coefficients (eg the time taken to fatten cattle and the grade of meat obtained). The appraiser would naturally resist the temptation to adjust the values of coefficients in order to obtain a predetermined internal rate of return.

Another pitfall is to assume that the ratios between the unit prices of outputs and inputs remain constant over time whereas, for example, the price of beef may slump in relation to say average costs of inputs.

Sensitivity and risk analysis

Sensitivity analysis is concerned with identifying those input and output items (variables) which most affect the magnitudes of the three measures: the net present value, the benefit/cost ratio and the internal rate of return. The sensitive variables are those on which the planner has to concentrate and ensure that he has obtained the best possible data for their calculation.

To calculate a sensitivity analysis the planner changes the value of only one variable, keeping all the rest constant, and so is able to gauge the effect of changes in the value of a particular variable on the three measures. For details of a "short cut method", see Appendix 9.

A risk analysis is advisable when certain variables are "very sensitive", ie relatively small changes in their values have a considerable effect on the financial viability of the project. This involves taking a range of possible values for each sensitive variable (the variable at risk) instead of one unique value. A cost/benefit exercise is now made and the particular value used for each variable at risk is selected by using weighted probabilities and the resultant internal rate of return graphed. The exercise is then repeated until the shape of the graph is stabilised. The degree of risk involved in the project can be assessed from the graph (see Appendix 10 and 24).

A risk analysis is desirable for rangeland projects in semi-arid areas. Carrying capacity of the land is a very sensitive variable which is greatly affected by rainfall in a particular year. It would be useful to allow for the probability of a drought in each year of the projection. This can readily be done by risk analysis. Normally market or shadow prices are used. These are assumed to

remain constant over the time-span of the projection unless the physical quality of the item is expected to change (for example cattle grades at slaughter). If, however, there is reason to believe that unit prices of costs are more likely to rise over time than unit prices of output (or vice versa) then this should be allowed for especially if a sensitivity analysis shows that prices are an important coefficient - a highly probable situation.

Estimated annual cash flows should be examined carefully especially as regards the point of time at which the project generates enough cash surplus to provide its own working capital and service its debts. The importance of this point can be tested by sensitivity analysis. Any major delay may well threaten the viability of a project and leave producers in a position where they will be unable to repay their debts. Given the management constraints likely to be operative in some developing countries, it is as well to take a conservative view of the benefits likely to stem from new investments, especially their timing.

A cost/benefit analysis involves considerable calculations which are intensified if sensitivity and risk analysis are also carried out. Computers, the necessary programmes and trained staff are unlikely to be available in many developing countries for such work. There are, however, suitable desk machines available which can be programmed and these offer "an appropriate technology" to planners*. Computers and programmable calculators are not essential for cost/benefit analysis, as the following example shows. With risk analysis however, a large computer is essential, given existing methods of calculation.

The next section gives a worked example of a cattle ranch appraisal which covers breeding, rearing and finishing for beef. This combination requires in an appraisal a fairly complex demographic calculation of changes in cattle population over time and another calculation of residual values at the end of the projection, since part of the benefit from the investment is the build-up of a stock of cattle of better quality. An example of an appraisal of a fattening enterprise for a small farm situation is also given, followed by an illustration of the determinants of profitability in beef fattening.

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* Suitable programmable calculators for herd simulation and the calculation of internal rates of return are the Texas Instruments 59 and the Hewlett Packard 67. These cost about £200.

A RANCH PROJECT : AN EXAMPLE OF AN APPRAISAL

This example is given in order to demonstrate the type of calculations involved. The reader is strongly recommended to work through the tables besides reading the text. The example is based on hypothetical data and the coefficients used should not be applied to other situations. The project relates to a cattle ranch where, after the establishment of a foundation herd of 2,000 cows, income comes from the sale of surplus breeding stock and 4-year old steers for slaughter. Because of the time-lag between starting the ranch and the sale of the resultant homebred cattle, there is no return to the investment until the fourth year of operation.

The example is based on hypothetical market prices for inputs and outputs, and is concerned with only direct costs and benefits. Consequently it is a financial appraisal as opposed to an economic appraisal.

The herd projection

The cattle herd projection is the starting point of an appraisal involving cattle breeding. Given the sex and age composition of the foundation herd, then birth and death rates, sale ages of homebred steers and ages at maturity of homebred heifers, the culling rates for breeding cows and bulls, together with the purchases of replacements, will determine the size and composition of the herd in subsequent years.

Table 5 illustrates such a herd projection for the first four years of the example, based on the assumed demographic coefficients given in the footnote of the table. The ranch starts with a foundation herd of 2,000 cows and 80 bulls, (a bull/cow ratio of 1:25). By the end of year 1, 100 cows and 4 bulls have died, (an annual mortality rate of 5%). The surviving cows have produced 1140 calves that survive to the end of year 1, (an effective weaning rate of 60%). Half these calves are male and half female.

In year 2 these calves enter the 1-2 year age groups, 570 males and 570 females. The subsequent movement of these calves through the age groups is shown in Table 5; for example 541 males survive to the end of year 2, 514 males survive to the end of year 3 and 488 to the end of year 4 when they are sold for slaughter. In each year numbers are reduced by a 5% annual mortality rate.

The projection becomes rather more complicated by the end of year 4 since besides the first sales of homebred steers, the heifers born in year 1 are now old enough to enter the breeding herd. To make way for them so avoiding overstocking, 10% of the existing cows are culled, while to avoid inbreeding, all the bulls are replaced.

The calculation of a livestock population projection is a tedious exercise and calls for considerable accuracy, (although computer programmes are available, some appraisers still do the work by hand while others use programmable calculators).

A livestock reconciliation table can be very helpful. It is based on the following formula:-

Number at the beginning of the year <u>plus</u> number born in the year <u>plus</u> number purchased in the year

<u>equals</u>

number left at the end of the year <u>plus</u> sales <u>plus</u> deaths

Taking year 4 for example (see Tables 5 and 6), it will be seen that:-

4868 (Nos at the beginning of the year)	+	66 (purchases)	+	978 (births)
= 5912 =				
4951 (Nos at the end of the year)	+	716 (sales)	+	245 (deaths)

Table 6 gives details of the livestock numbers reconciliation relating to Table 5.

Two general points should be mentioned here; the appraiser has to decide how to vary the technical coefficients assumed over time, and also to avoid "overstocking" a ranch in his projection. As regards technical coefficients, it is common to allow for a rise in birth rates and a fall in death rates, but caution should be used. The problem of overstocking can be

TABLE 5 HERD COMPOSITION: YEAR 1 TO END OF YEAR 4 (RANCH PROJECT)

(Numbers of Cattle)

TYPE OF STOCK	YEAR 1		YEAR 2		YEAR 3		YEAR 4		End (B)
	Beginning	End	Beginning	End	Beginning	End	Beginning	End (A)	
Breeding Cows	2,000	1,900	1,900	1,805	1,805	1,715	1,715	1,629	1,954
Breeding bulls	80	76	76	72	72	68	68	65	66
Calves under 1 year old	-	1,140	-	1,083	-	1,029	-	978	-
Females (Heifers)									
1 - 2 year old	-	-	570	541	541	514	515	489	489
2 - 3 year old	-	-	-	-	541	514	514	488	489
3 - 4 year old	-	-	-	-	-	-	514	488	488
Males (Steers)									
1 - 2 year old	-	-	570	541	542	514	514	488	489
2 - 3 year old	-	-	-	-	541	514	514	488	489
3 - 4 year old	-	-	-	-	-	-	514	488	488
TOTAL CATTLE NUMBERS	2,080	3,116	3,116	4,042	4,042	4,868	4,868	5,601	4,951

Notes

(1) Year 4 End A - Before sales, purchases and transfers between age groups
B - After, see Table 6, Reconciliation of Livestock Numbers.
so 4,951 (total B) = 5,601 (total A) - 650 (excess of cattle numbers sold over cattle purchased).

(2) Technical coefficients assumed
a. Effective weaning rate, 60% (Number of calves surviving to weaning per 100 cows).
b. Half the calves born are male and half female.
c. Mortality all stock over 1 year old, 5% annually.
d. Bull/Cow ratio, 1:25
e. Home bred heifers first bulled at 48 months old.
f. 100% of bulls and 10% of cows culled at the end of Year 4.
g. Sale age home bred steers. 48 months

catered for by either placing a maximum on the number of breeding cows and selling off the surplus, or by a more complex calculation of fitting stock numbers to carrying capacity, through expressing both totals in terms of animal units (see Appendix 5). A further refinement could be the avoidance of understocking in the early years by relating purchases of additional stock to the carrying capacity; for example, bringing in immature steers for fattening.

In the interest of simplicity and brevity such refinements are omitted from the present example and in addition the detailed population projections of Tables 5 and 6 stop at the end of year 4. In practice of course they would continue for the whole period covered by the appraisal.

TABLE 6 RECONCILIATION OF LIVESTOCK NUMBERS (RANCH PROJECT)

(Cattle Numbers)

Year	Opening Numbers	Purchases	Births	Sales	Deaths	Closing Numbers
Year 1	-	2,080	1,140	-	104	3,116
Year 2	3,116	-	1,083	-	157	4,042
Year 3	4,042	-	1,029	-	203	4,868
Year 4	4,868	66	978	716	245	4,951

Calculations of the annual cash budget

Table 9 gives a hypothetical cash budget relating to the first four years of the example. It incorporates cash inflow and outflow figures relating to cattle transactions together with other cost items which are detailed in the footnote to Table 9. These include an initial investment in ranch infrastructure (buildings, roads, dips etc) and annual operating costs. The latter consist of a fixed and variable cost component. A charge of £4,000 is made for fixed costs (management expenses, repairs, renewals etc) and variable costs consist of £2 annual charge per head of cattle, excluding calves, to cover herding labour, vet and medicines and other items the costs of which vary with the number of cattle kept.

TABLE 7 REVENUE FROM SALES (RANCH PROJECT)

Number of Head Sold

	Price per Head £s	Year 1	Year 2	Year 3	Year 4
Cull Bulls	40	-	-	-	65
Cull Cows	25	-	-	-	163
48 month Males	50	-	-	-	488
Total					716
Total Sale Revenue £s		-	-	-	31,075

TABLE 8 CATTLE PURCHASES (RANCH PROJECT)

Number of Head Bought

	Price per Head £s	Year 1	Year 2	Year 3	Year 4
Breeding Bulls	150	80	-	-	66
Breeding Cows	50	2,000	-	-	-
Total Cost £s		112,000	-	-	9,900

Purchase and sales transactions follow from the livestock projection. Livestock sales are the only income source in the example and Table 7 gives details of the numbers sold, prices per head and the total sum of money involved. Table 8 provides similar data for purchases.

Table 9 is concerned with cash inflows and outflows. It will be seen that the ranch accumulates a cash deficit during the first three years, as no cattle are sold. In practice these deficits would have to be met by either further injections of the owner's capital or by borrowing, otherwise there would be a cash-flow problem and the ranch would cease operations. If money were borrowed, then interest payments would be incurred, together with the liability to repay the principal of the debt. If a project cannot generate sufficient income streams to service and repay its debts then it is obviously financially unviable and its implementation can only be justified on social grounds.

The presence of a negative cash balance in the first three years of the example, is the direct consequence of the time-lag between starting a breeding herd and the sale of the resultant progeny or in other words between the initial investment and the generation of the subsequent income streams. This time-lag highlights the need for the planner to consider arrangements for the provision of working capital in the initial years of the project until it generates sufficient funds to be self-financing.

Cost/Benefit analysis

A cost/benefit analysis is concerned with the incremental benefit and costs resulting from the new investment, in the form of annual income and cost streams. It is not concerned with deficit financing as such. A comparison between Tables 9 and 10 illustrates the difference between a cash budget and a cost/benefit analysis. In years 1-3 where there are no income streams, the cost outflows of Table 9 become the net cash flows of Table 10. After year 3 when income from cattle sales is realised, the net cash flows of table 10 are these annual streams less cash outflows.

As a cost/benefit analysis is made over a longer period of time than the four years discussed so far, the projection is now lengthened to 12 years. To simplify the calculation it is assumed that from year 5 to year 11, costs and benefits and consequently net cash flows stabilise at £15,000, £35,000 and £20,000 annually respectively. While costs are assumed to remain at £15,000 in year 12, the income streams are augmented by residual values since this is the last year of the projection.

TABLE 9 A SIMPLIFIED CASH BUDGET (RANCH PROJECT)

	YEAR 1	YEAR 2	YEAR 3	YEAR 4
CASH INFLOW (£)				
1. Initial Investment Cattle	112,000	-	-	-
Infrastructure	18,000	-	-	-
2. Sales	-	-	-	31,075
3. All other Income	-	-	-	-
Total Cash Inflow	130,000	-	-	31,075
CASH OUTFLOW (£)				
1. Initial Investment Cattle	112,000	-	-	-
Infrastructure	18,000	-	-	-
2. Fixed Costs	4,000	4,000	4,000	4,000
3. Variable Costs	4,056	6,075	7,881	9,492
4. Purchases of Cattle after the 1st year	-	-	-	9,900
5. All Other Costs	-	-	-	-
Total Cash Outflow	138,056	10,075	11,881	23,392
Annual Cash Balance*	-8,056	-10,075	-11,881	+7,683

Notes

a. Sales and purchases of cattle from Tables 4, 7 and 8.

b. Initial Investment of £18,000 to cover ranch infrastructure (water installations etc).

c. Annual fixed cost of £4,000.

d. Variable Cost charged at £2 annually per head of cattle excluding calves.

* A deficit cash balance would have to be met by additional cash injections (cash inflows). If these are borrowed, an interest charge should be included.

TABLE 10 INCREMENTAL BENEFITS, COSTS, NET CASH FLOWS, NET PRESENT VALUE AND BENEFIT/COST RATIO 10% DISCOUNT RATE (RANCH PROJECT)

£s

YEAR	NOT DISCOUNTED		NET CASH FLOW	10% DISCOUNT FACTOR	DISCOUNTED AT 10%		NET CASH FLOW	SUB TOTAL NET CASH FLOW
	INCREMENTAL BENEFITS	INCREMENTAL COSTS			INCREMENTAL BENEFITS	INCREMENTAL COSTS		
1	-	138,056	-138,056	1.0000	-	138,056	-138,056	- 157,033
2	-	10,075	- 10,075	0.9091	-	9,159	- 9,159	
3	-	11,881	- 11,881	0.8264	-	9,818	- 9,818	
4	31,075	23,392	+ 7,683	0.7513	23,346	17,574	+ 5,772	+ 127,715
5	35,000	15,000	+ 20,000	0.6830	23,905	10,245	+ 13,660	
6	35,000	15,000	+ 20,000	0.6209	21,732	9,314	+ 12,418	
7	35,000	15,000	+ 20,000	0.5645	19,758	8,468	+ 11,290	
8	35,000	15,000	+ 20,000	0.5132	17,962	7,698	+ 10,264	
9	35,000	15,000	+ 20,000	0.4665	16,328	6,998	+ 9,330	
10	35,000	15,000	+ 20,000	0.4241	14,844	6,362	+ 8,482	
11	35,000	15,000	+ 20,000	0.3855	13,493	5,783	+ 7,710	
12	154,200*	15,000	+139,200	0.3505	54,047	5,258	+ 48,789	
TOTAL					205,415	234,733	- 29,318	-29,318

At 10% Discount Rate

Net Present Value = -£ 29,318

Benefit/Cost Ratio = $\frac{£205,415}{234,733}$ = 0.875

* This includes allowances for residual values and changes in cattle valuations.

Residual values

Two types of residual values are taken into account here, the first relates to the investment in the infrastructure of the ranch, the second to changes in cattle valuations during the appraisal period.

a. Calculation of the residual value of ranch infrastructure is done as follows:

Initial cost in year 1 = £18,000

Assuming straightline depreciation and a 20 year life,

Then at the end of year 12 the residual value is

$\frac{£18,000}{20} \times 8 = £7,200$

(ie at the end of year 12, there are still 8 years life left)

b. Calculation of the changes in cattle valuations. During the project period cattle numbers should increase and their quality improve. So it is assumed here that the total value of the cattle on the ranch in year 1 will have doubled by the end of year 12, giving an increase in valuations of £112,000.

The result of these additions to incremental benefits in year 12 is that the net cash flow is swollen to + £139,200; the highest for any year in the projection but as it comes at the end, its effect in the final analysis is very much influenced by discounting.

Discounting

This is done in order to obtain the present values of future income, cost and net cash flow streams. In Table 10, these are discounted by using a 10% factor; a rate commonly employed in appraisal work. The streams for each year are multiplied by the relevant factor for that year; for example in Table 10, by 1 in year 1, 0.9091 in year 2 and so on to year 12 where the factor is only 0.3505. The result of course is to give greater weight to streams in the early years than in the late years; a point of great significance when there are negative net cash flow streams in the initial years of the project and positive streams in the later years.

The discounted net cash flows are then added up to obtain the net present value at 10% discount rate. This is negative - £29,318, since the more heavily discounted positive net cash flow stream of years 4-12 are insufficient to offset the less heavily discounted negative streams of years 1-3, see Table 10.

The cost/benefit ratio is obtained by dividing the total discounted benefits by the total discounted costs. This is 0.875 at 10%; for every £1 spent, £0.875 is obtained in return.

The internal rate of return

The internal rate of return, "the yield on the investment", is that rate of discount which equates the positive and negative cash flows so that they cancel each other out and the net present value is zero. In Table 10, it follows that, as the discounted positive cash flows are too heavily discounted to equate the negative cash flows, then the internal rate of return is lower than 10%. What rate of discount will balance the two, can only be found by iterative calculations in which the net cash flows shown in the 4th column of Table 10 are discounted by other factors (lower than 10%) until the two broadly balance, ie when the net present value approaches zero.

TABLE 11 CALCULATION OF THE INTERNAL RATE OF RETURN (Ranch Projects)

£s

Discount Rate %	Total of Discounted Net Cash Flows		Net Present Value
	Positive Streams	Negative Streams	
10	127,715	157,033	-29,318
8	148,460	157,570	- 9,110
7½	154,280	157,710	- 3,430
7¼	157,292	157,778	- 486
7	160,388	157,849	+ 2,539

Approximate internal rate of return = 7¼%

In the present example, the discount rate was reduced by 1 until the two rates either side of the zero value of the net present value were obtained; 8% gave a negative value and 7% a positive one, see Table 11. The next step was to use a discount rate of 7½%; this still gave a negative result, showing that the internal rate of return lay between 7½% and 7%. The final recalculation of the

net cash flows using a $7\frac{1}{4}\%$ rate, resulted in a very low negative net present value and this rate is taken as the approximate value of the internal rate of return. In view of the many assumptions involved in the data on which the calculation is based, any further degree of precision is unnecessary and carries the danger of conveying an impression of spurious accuracy.

Tables of discount factors are readily available, but if they are not detailed enough, then it is comparatively easy for an appraiser to calculate his own rates using the simple formula given in Appendix 8, or to use a programmable calculator which has special programmes written for determining net present values or internal rates of return.

Finally, the internal rate of return can only be calculated where there are both positive and negative annual income streams over the life-span of the project. If all the streams are negative, then obviously the project is unviable; if all are positive, then the cost/benefit ratio should be used instead.

Economic analysis

In making an economic appraisal of this project, the approach would be somewhat different. If the cattle were purchased outside the country, the real foreign exchange cost of buying them would need to be calculated, using a shadow price for foreign exchange. If the cattle were purchased within the country, a comparison would need to be made of their productivity within the ranch against their productivity outside the ranch. This would entail assessment of the herd coefficients in the "without project" situation, in order to project the output of the herd for comparison with the projections made above. The difference in output over time would form the basis for calculating net benefits to the economy from the project.

A SMALLHOLDER CATTLE FATTENING PROJECT

In this project, settled smallholder cultivators with mixed farming systems are given loans to purchase breeding and fattening animals. The initial loan amount is small (about £350 in 1976 prices) and provides the farmer with one yearling heifer and three steers for fattening, as well as money to build a simple stall and purchase a certain amount of concentrated feed (see Table 12). The animals are to be fed on crop by-products and leucaena, a fast growing forage tree which can be grown in a hedgerow and harvested frequently for handfeeding after drying the leaves to reduce the mimosine content. It is essential that expert advice be followed in this matter.

The young heifer is mated by artificial insemination (AI) in the second year and produces a male calf in the third year which is fattened in the fourth year and sold in the fifth. A female calf is produced in the fifth year which is retained and produces a calf in the eighth year. By the ninth year the original cow is culled and replaced by an in-calf heifer maintaining the breeding herd at three (Table 13). Initially three steers are purchased each year at 160 kg and fattened for sale in the following year at 274 kg liveweight. As the breeding herd is built up to three, sufficient calves are produced to replace cull cows and reduce steer purchases to one a year.

The system stabilises with a herd of three cows and three animals being sold a year after the tenth year, producing an incremental income of £206, after debt repayment between years 2 and 9 (Table 14). The financial rate of return is 13%, calculated on the basis of the incremental financial balance. Note that debt repayment is ignored for this calculation. The farmer enjoys a positive cash surplus (while repaying the loan) as a result of the investment in all years save one (year 9).

As with the previous example, the economic analysis would need to consider the productivity of the animals if they were not bred and fattened by smallholders in this way. The difference between the "with" and "without" project streams would determine the net benefits attributable to the project.

TABLE 12 SMALLHOLDER CATTLE BREEDING AND FATTENING MODEL: INVESTMENT COSTS IN YEAR 1

	Cost per farm (£)
Capital Investment	
10 kg of *Leucaena* (high yielding variety)	0.7
Stall	33.0
One heifer (1-2 years)	80.0
Other contingencies	5.7
Working Capital	
AI service fee	1.3
3 immature steers (1-2 years)	200.0
Veterinary charges	4.0
Concentrates at 2 kg rice bran per animal unit for 4 months	28.8
Total Investment	£353.5

TABLE 13 SMALLHOLDER CATTLE BREEDING AND FATTENING MODEL: HERD PROJECTIONS

Herd Composition	At end of year										
	1	2	3	4	5	6	7	8	9	10	11–20
Breeding cows and replacements	–	1	1	1	1	1	2	2	3	3	3
Calves weaned	–	–	1	–	1	–	1	1	2	2	2
Heifers 1–2 years	1	–	–	–	–	1	–	1	–	1	1
Steers 1–2 years	3	3	3	3	3	3	3	3	3	2	2
Purchases											
Heifers 1–2 years	1	–	–	–	–	–	–	–	–	–	–
Steers 1–2 years	3	3	3	2	3	3	3	3	2	1	1
In calf heifer											
Sales											
Cull cows	–	–	–	–	–	–	–	–	–	1	–
Animals 2–3 years	–	3	3	3	3	3	3	3	3	3	3

Technical coefficients: weaning rate 60%; cow mortality 3%; cow cull rate 10%; steer liveweight gain 300 grams/day; steer purchase liveweight 160 kg; steer sale liveweight 274 kg.

TABLE 14 SMALLHOLDER CATTLE BREEDING AND FATTENING MODEL: FINANCIAL PROJECTIONS (£)

Year	1	2	3	4	5	6	7	8	9	10	11-20
Sales of Cattle	-	329.0	329.0	329.0	329.0	329.0	329.0	329.0	329.0	409.0	329.0*
Operating Costs Steers purchase	200.0	200.0	200.0	133.3	200.0	200.0	200.0	200.0	133.0	67.0	67.0
In calf heifer	-	-	-	-	-	-	-	-	-	100.0	-
Veterinary expenses	4.0	4.0	4.0	4.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0
AI charges	1.3	1.3	1.3	1.3	1.3	1.3	2.6	2.6	3.9	3.9	3.9
Concentrated feed	28.8	28.8	28.8	28.8	36.0	36.0	36.0	43.2	43.2	43.2	43.2
Miscellaneous	5.7	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Total operating costs	239.8	237.4	237.4	170.7	245.6	245.6	246.9	255.1	189.4	223.4	123.4
Cash inflow	353.5	329.0	329.0	329.0	329.0	329.0	329.0	329.0	329.0	409.0	329.0
Debt service + (principal + interest)		21.2	77.5	77.5	77.5	77.5	77.5	77.5	77.5	-	-
Cash outflow	353.5	258.6	314.9	248.2	323.1	323.1	324.4	332.6	266.9	223.4	123.4
Surplus cash at end of year	-	70.4	14.1	80.8	5.9	5.9	4.6	(3.6)	62.1	185.6	205.6
Incremental financial balance	(353.5)	91.6	91.6	158.3	83.4	83.4	82.1	73.9	139.6	185.6	205.6*

Cows and heifers are valued at £80, steers at £67 and calves at £40.

+ 9 year loan, 2 years grace period, at 12 per cent interest

*at year 20, the salvage value of the herd is an additional £533.3

Appendix 1

USEFUL REFERENCES

A. BASIC TEXTS

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Appendix 2

GLOSSARY OF TERMS

Agisting Cattle

A practice in which cattle belonging to other owners are taken in for a charge. The person providing the keep avoids the capital outlay involved in purchasing the animals and receives a predetermined cash payment for the use of his resources so reducing risk and uncertainty.

Annual Off-Take Rates

The percentage of the total number of cattle which are economically disposed of each year. This depends on the ages at which cattle reach saleable condition and their owners' attitudes as regards production for the market. It is useful to distinguish between commercial off-take and total off-take, as an increase in commercial off-take may be at the expense of pastoralists' own consumption rather than reflecting an increase in herd productivity.

Benefit/Cost Ratio

See cost/benefit analysis.

Break-even Through-put

That level of output required to cover costs, not to show a profit. Output is normally defined in this context as the physical volume of production multiplied by price. Costs include both a fixed and a variable element. Total fixed costs by definition do not vary with the volume of production hence fixed costs per unit produced fall with increasing production. Total variable costs vary directly with the volume of production, hence variable costs per unit produced, can be regarded as a constant charge. Total costs per unit produced (fixed and variable cost) therefore fall with increasing output, hence the need to utilise the full capacity of any investment with a high fixed cost element; for example a meat processing plant.

Buyers' Rings

Middlemen often make informal arrangements not to compete against each other. Such arrangements can include some form of price fixing and the allocation of market shares. Buyers' rings are especially associated with cattle auctions.

Cost-Benefit Analysis

The standard method of appraising an investment project; for general expositions of the method, the reader should consult the references given in Appendix 1. If the worked example is followed through in the text, the reader should gain some idea of how to carry out a cost/benefit analysis of a cattle project.

The basic steps in a cost/benefit analysis are the identification and quantification of annual income (benefits) and cost streams over the anticipated life of an investment project. In order to express future benefit and cost streams at varying points of time, in terms of present values, the former are discounted. In theory the discount rate should represent the opportunity costs of capital, but the usual convention is to adopt a rate of 10%.

Net present value is total discounted benefits minus total discounted costs. The benefit/cost ratio is total discounted benefits divided by total discounted costs.

Normally costs and benefits are valued at prevailing market prices at the time of the appraisal. These however could be distorted by imperfect competition, government price fixing and the local currency may be overvalued. Consequently, it could be argued that market prices should be adjusted to allow for these distortions (shadow prices are adjusted market prices). Because of the difficulties involved, however, this is not normally done except with exchange rates where a project has a high foreign trade component.

Normally benefits and costs are confined to those directly associated with the project and ignore possible spillovers (see glossary) and other indirect effects.

Where costs and benefits are confined to those directly associated with the project and are valued at market prices, then the analysis is termed a financial appraisal. Where indirect costs and benefits are included and/or some form of shadow pricing carried out, then the analysis can be termed an economic appraisal.

Crush

A cattle pen constructed in the form of a narrow corridor which enables cattle to be handled easily from the outside. Through penning animals in a crush, cattle can be examined individually and treated as necessary.

Demonstration Effects

Where new practices are seen in operation by other producers who may then adopt them themselves. Demonstration effects have a major influence on the rate of diffusion of innovations.

Economic Appraisal

See cost/benefit analysis.

Effective calving rate - see Weaning rate

Evolutionary Approach

An evolutionary approach to development means leaving fundamental changes in farming systems and the organisational structures of the farming and agricultural marketing systems to build up over time without any sudden drastic intervention of an outside body - usually the state. The evolutionary approach depends basically on the economy's response over time to free market forces. See also the opposite situation - The transformation approach.

Financial Appraisal

See cost/benefit analysis

Indirect Costs and Benefits

See cost/benefit analysis

Linear Programming

A method used for maximising or minimising a particular factor given specified constraints - in the context of this manual, the feed costs required to bring a beef animal to a given slaughter weight subject to the nutritive requirements of the animal and the nutritive contents of alternative feeding stuffs.

Linear programming is a major tool in farm management economics and is discussed in standard textbooks on that subject. Because of the amount of computations involved in working through a linear programme, it is usual to do the calculations on a computer using a standard package programme - see also Appendix 6.

Linkages

See system analysis.

Market Prices

See cost/benefit analysis.

Net Present Value

See cost/benefit analysis

Package Approach

A collection of measures designed to remedy some of the major obstacles to raising productivity. For example the beef production sector may be considered to be held back partly by the lack of marketing and credit facilities, so a beef production project could well have marketing and credit components.

Opportunity Costs

A fundamental concept in economic theory. Basically an opportunity cost is the loss in production elsewhere when resources are locked up in their present use - the output foregone.

Risk Analysis

An addition to cost/benefit analysis which copes with the problem of risk, see Appendix 10.

Sensitivity Analysis

An addition to cost/benefit analysis which enables the most important factors to be identified and ranked; see Appendix 9.

Shadow Prices

See cost/benefit analysis.

Spillover Effects

Some secondary consequences of the implementation of a project which can be either adverse or beneficial or expected or not; secondary consequences because they were not included among the major factors concerned when the project was initially drawn

up, mainly because they were not considered to be directly involved. For example an increase in producers' incomes could lead to an increase in off-farm employment in rural areas due to the expansion of shops and service industries.

Systems Analysis

Systems analysis is originally an engineering concept in which a mechanical process such as a manufacturing production line is studied in depth in order to secure its smooth running and efficiency. The line is seen as a chain of component processes, each of which has forward and backward linkage effects; forward towards the final production of the finished article, backward towards the input of raw materials necessary for production. In order to control the working of the chain there are positive and negative feedbacks; these are termed cybernetic features. The whole production line then functions as a single system.

The method is now standard in operations research and is applied in fields outside engineering. In beef production for example it could be applied to all the processes involved from the breeding of the original animal to the distribution of a can of corned beef.

The need to study agricultural systems and their component parts has been reinforced by the advent of a new scientific journal. The reader interested to learn more is referred to "Agricultural Systems" Vol. 1 No. 1, January 1976, which is devoted to an exposition of the subject.

Transformation Approach

A transformation approach is where economic and/or technical change is precipitated by sudden drastic outside intervention. An example is where the state encloses former nomadic grazing land for mechanised arable cultivation. See also evolutionary approach.

Weaning Rate

The average number of calves surviving to weaning per year, expressed as a percentage of the number of breeding cows surviving at the end of the period. The weaning rate has two main components: the calving rate and the calf mortality rate. It is usually better to give both of these ratios separately so that the underlying situation is clear to the project planner, and appropriate means of improvement can be devised.

Appendix 3

YIELD FROM ONE STEER CARCASE

360 Kgs liveweight, 52% Killing out percentage. *

a) Liveweight, Carcase Dressed Weight, By-Products and Losses at Slaughter

	Kgs	%
Liveweight	360	100
Loss of Weight at Slaughter (Shrinkage and contents of stomach)	58	16
By-products	115	32
Cold Carcase Dressed Weight	187	52

b) Composition of By-Products

	Kgs	%
Hide	29	8
Intestines, stomach, casings and bladder	22	6
Skull, legbones, horns, hoofs and tail	20	5½
Blood	12	3½
Fat	11	3
Tongue, brains and meat from head	7	2
Heart, liver and kidneys	7	2
Lungs, windpipe and glands	7	2
Total	115	32

* Figures relate to a livestock project in the Central Rainlands of the Sudan (40)

Appendix 4

DEMAND PROJECTIONS

Demand projections for beef may be based on the relationship

$$d = p + gn + pgn$$

where

d is the annual growth rate in demand;

p is the population growth rate;

g is the rate of increase in per capita income;

n is the income elasticity of demand for beef.

Applying d to consumption in base year (C_t) permits projection of consumption in any future year $C_t + x$.

The project planner has therefore to select values of p, g, n, and C_t to obtain a projection for $C_t + x$.

In most countries values for population growth rate (p) and growth in per capita income (g) will be available from the national planning agency. Since these may be target values and hence err on the side of optimism, the stated values may be reduced (for growth in per capita consumption) and increased (for growth in population) for alternative projections under "high" and "low" assumptions. For long-term projections of demand it will be necessary to take account of changes in population and income growth rates over time.

For base year consumption (C_t) a figure on per capita consumption may be available from the Central Statistical Bureau or the Ministry of Agriculture. It will be useful to check this by the food balance sheet method for consistency with other official statistics relating to meat imports, meat exports, and slaughter rates; applying the appropriate conversion rates where necessary. Thus

annual beef consumption = beef produced domestically plus beef imports
less beef exports plus or minus stock changes.

The income elasticity of demand for beef "n" measures the percentage change in expenditure on beef in response to a one per cent change in income. Ideally values for "n" will be available from the national planning agency or the Ministry of Agriculture. Where such estimates are not available locally the project planner may take the national estimate made by FAO, or estimate an income elasticity himself using the well established procedures fully described in "Income Elasticities of Demand for Agricultural Products", FAO, Rome, 1972. Again, when projections are to be made over a long period, consideration should be given to adjusting the value of "n" to account for Engel's Law. More sophisticated analysis will also take into account trends in urbanisation and changes in income distribution.

The example which follows is taken from the Philippines (25) where beef is derived from both cattle and carabao (water buffaloes). There is an initial problem of determining the base year level of beef consumption. Population and per capita income growth rates were taken initially from the national planning agency and some adjustments made to obtain projections under high and low assumptions. A fairly conservative estimate of the income elasticity of demand was taken and decremented over time, so that the overall projection of demand could be seen to be a conservative one.

According to food balance sheet estimates made by the National Economic and Development Authority or NEDA the share of beef and carabeef in total meat consumption increased from an average of 16 per cent for the period 1955-57 to an average of 19 per cent for the period 1972-74; most of this increased share being attributable to increased carabeef consumption. Carabeef consumption showed an average annual growth rate of 8.5 per cent over this time, with poultry consumption growing at 5.1 per cent and beef at 3.0 per cent. Pork continued to account for more than half total meat consumption but its share declined.

The NEDA data indicate a fluctuating annual consumption of beef in the period 1955-65, followed by a sustained increase in the period 1966-1974. Estimates of annual consumption of carabeef also fluctuate markedly, but show a sustained increase in recent years. Some of these fluctuations may be ascribed to supply variations occasioned by disease outbreaks but there are limitations too in the method of estimating consumption.

The available supply of beef and carabeef meat is estimated on the basis of number of head slaughtered at registered slaughter houses, but there is as yet no satisfactory means of estimating on-farm or backyard slaughtering. The household survey data of the Department of Agriculture's Special Studies Division indicate that forty two million Philippine consumers ate on average 3 kg of beef and carabeef per head in 1975. This is equivalent to 126 thousand tons of beef and carabeef. It is estimated that the annual offtake of animals from the national cattle herd is about 200,000 animals. At an average carcase weight of 190 kg (including edible offals and organs) this would imply the annual slaughter of some 354 thousand carabao.

As discussed earlier, this rate of offtake from the carabao herd would not be sustainable in the longer term, but could be consistent with a transition from a work animal herd to a meat producing herd. To summarise, the national consumption of beef and carabeef in 1975 appears to have been met as follows:

Total consumption of beef and carabeef:		126,000 tons
of which:		
imported beef	:	9,500 tons
from domestic cattle herd	:	49,300 tons
from domestic carabao herd	:	67,200 tons
Total carabao population	:	2,725 thousand
carabao slaughtered	:	354 thousand
annual rate of offtake	:	13 per cent
average age at slaughter	:	7.7 years
Total cattle population	:	1,737 thousand
cattle slaughtered	:	290 thousand
annual rate of offtake	:	17 per cent
average age at slaughter	:	5.9 years

In projecting demand, assumptions need to be made about rates of growth of population and per capita income, and of the income elasticity of demand for beef and carabeef.

Because the projection period is a long one (twenty five years) account was taken of the likelihood of diminishing values for the population growth rate and for the income elasticity of demand. The starting value for income elasticity of demand used in the projections was 0.8 a value less than the 0.9 estimated by the Special Studies Division of the Department of Agriculture, and very much lower than that of FAO (1.20). For the "high" projection of demand, the income elasticity of demand was decremented by .01 annually to a closing value of 0.56 in the year 2000; for the low projection of demand, income elasticity was decremented by 0.02 annually to a closing value of 0.32 in the year 2000. An initial rate of population growth at 3.0 per cent declining to 2.7 per cent in 2000 was taken for the "high" projection, and for the "low" projection the rate declines to 2.0 per cent in 2000. Per capita income growth was held constant at 4 per cent annually for the "high" projections, and at 3 per cent for the "low" projection. Thus the assumptions underlying the demand projections are quite conservative. They imply growth rates in total consumption of beef and carabeef of 4.2 per cent annually (low) and 5.6 per cent (high). Per capita consumption would increase from 3.0 kg to 4.50 kg (low) or 5.76 kg (high).

Appendix 5

TABLE OF ANIMAL UNITS

Animal or stock units are a method by which the numbers of animals of different species, ages and sexes can be expressed in terms of a common denominator. This is done by expressing one animal of each class as a value on a scale. Normally the point 1.0 on the scale is allocated to a mature bull of good size (cattle breeds differ in size) and the other classes are ranked in terms of their comparative feed requirements in relation to a mature bull.

Ideally local tables for animal units would be available and the appraiser should use this material. The tables given here were used by the writer in Kenya and due caution is urged in applying these figures - take local advice on their relevance.

	Animal units	
Per Head	Indigenous Cattle (1)	Improved Cattle (2)
Breeding Bull	0.8	1.0
Breeding cow (3)	0.6	0.8
Steer or heifer 3-4 yrs	0.5	0.6
Steer or heifer 2-3 yrs	0.3	0.4
Steer or heifer 1-2 yrs	0.3	0.4

1) Indigenous cattle - small traditional Masai type.

2) Improved cattle, indigenous Zebu cattle improved by crossing with either local Boran or various exotic beef breeds.

3) Calves under 1 year counted in with breeding cows.

Improving cattle by cross-breeding often entails increasing body size and larger animals require more feed. Hence due allowance should be made for this in using scales of animal units in a project involving the improvement of cattle stocks over a period of time.

Animal units are used mainly in appraisal work for relating stock numbers to the carrying capacity of the land - the latter is expressed in terms of the area needed to sustain one animal unit for a given period of time.

Appendix 6

ANIMAL NUTRITION AND THE CONCEPT OF THE LEAST COST FEED MIX

(A) Nutrition

Beef production, viewed as a biological process, is the conversion of nutrients, usually feeds of plant origin, into meat for human consumption. The efficiency of feed conversion depends greatly upon the level of feed intake above that required for maintenance (ie the animal production level) but can be influenced by genetic factors and the balance between nutrients in the feed supplied. Of major economic importance is the balance between metabolisable energy supply and intake of crude protein as either pre-formed amino acids or non-protein nitrogen. An adequate intake of vitamins or vitamin precursors and suitable levels of minerals are essential for maintenance, growth and reproduction but these can be relatively readily supplied by injection or as supplements at comparatively low cost.

The primary factor affecting metabolisable energy intake is the digestibility of the diet, since in general cattle eat more of a diet with a higher digestibility. However digestibility in cattle depends upon the extent to which cellulosic or otherwise indigestible components of the diet can be broken down by micro-organisms. The activity of these micro-organisms is drastically reduced if the level of crude protein in the diet falls below 7-8%. In many developing countries beef cattle are raised on natural grazing or crop residues which are often of low digestibility and deficient in crude protein, resulting in poor reproductive performance in breeding animals and slow liveweight gain in slaughter stock. Where permanent pasture and fodder crops are available or concentrate feeds can be employed, performance is likely to be much improved provided the genetic potential of the livestock is adequate.

(B) Sources of Feed

(i) Natural grazing

Natural grazing includes grasses and browse composed of the leaves of trees and shrubs. Cattle prefer grasses but will ingest considerable quantities of browse, particularly during dry seasons or drought periods. Browse frequently contains more protein and minerals than the grasses. Tropical grasses are characterised by a faster growth rate, a higher degree of lignification and much lower digestibility and protein values compared with temperate grasses. Where grass growth is seasonal this leads to short periods of animal liveweight gain frequently followed by long periods when, at best, liveweight is maintained or when liveweight decreases. The carrying capacities of areas of natural grazing defined in terms of the area of land

required to support one animal unit, are frequently used as a guide to the extent to which they can be exploited without adversely affecting botanical composition or causing soil erosion. Because of year-to-year variations in rainfall, average carrying capacities may be meaningless in some areas and flexible systems of stocking and grazing management to make maximum use of the available dry matter should be encouraged. It appears however that once extreme overgrazing has been avoided there is frequently no obvious relationship between the levels of animal performance attained and the quantity of dry matter available to the animals. Of greater importance in many instances is the crude protein content of the dry matter ingested.

Recognition of the importance of crude protein in the nutrition of beef cattle on natural grazing has led to attempts to use protein supplements to offset deficiencies. Whilst in many instances this has been successful, in other circumstances the economic benefits of dry season supplementation of growing stock are substantially reduced by compensatory growth occurring in the following wet season. Protein supplementation may be particularly beneficial however in improving the reproductive performance of the breeding herd since this is an important factor in the economics of beef production. A further possibility is the adoption of grazing systems which encourage the growth of grass species which tend to have higher protein levels and which are also coincidently more palatable and digestible.

Where cattle are kept under traditional systems of management, priority has frequently been given to reducing overgrazing. Most often this has involved the provision of further watering points which open up new areas of pastures for exploitation. As interest increases in the commercialisation of beef production greater emphasis will be required on establishing grazing systems, employing fencing where necessary, which will not only increase the quantity of dry matter available but which will also improve its nutrient content. Where land is used communally, however, problems emerge of maintaining the grazing rights of individuals within a fenced grazing system.

(ii) Cultivated pastures, fodder crops and crop residues

Where land is available for the cultivation of permanent sown pastures a more regular supply of nutrients may be made available to the grazing animal. Seasonal variations in rainfall or temperature, however, may necessitate the conservation of herbage as hay or silage for use during periods of feed shortage. The use of protein and mineral supplements may also be advantageous in certain situations. Cultivated pastures may tend to revert to natural pasture over a period of time and grazing management should aim to prevent this.

Under many agricultural systems fodder crops, often leguminous, are grown as part of the normal farming rotations. During the periods when these crops are available, cattle may be well fed and considerable improvements in condition or liveweight may occur. As soon as these crops are cleared to make way for food or cash crops considerable feed shortages may occur severely limiting animal production levels. Crop residues such as straws, stovers and maize cobs may help to offset quantitative deficiencies but are of low nutritive value and sometimes have alternative uses as domestic fuel. It is possible that chemical treatment or mechanical processing of crop residues to improve nutritive value will become widespread in future years.

(iii) Agricultural by-products and compound feeds

By-products from the processing of agricultural crops used for animal feeding include principally oil seed residues, milling by-products and by-products of the sugar industry. Reject grains or flour may sometimes be available and a number of animal by-products can be incorporated into compound feeds. In addition a whole variety of minor ingredients may be added during the manufacture of compound feeds.

(C) Minimising feeding costs

Feeding costs under most situations form the largest element in the total costs of beef production. It may be argued that under nomadic pastoral conditions this is not the case but frequently use is being made of a natural resource which would have a higher productive value if properly managed. Frequently overgrazing may be destroying a national resource which will in future prove costly to replace either by instigating erosion control, by reseeding or through bush clearance. Where natural pasture is subject to grazing control costs will be incurred in terms of fencing costs and cattle handling facilities which effectively represent the costs of feeding the beef animal. However where natural pasture is used for animal feeding it must be recognised that real costs will prove difficult to assign.

The greatest difficulty in assigning a value to a feed occurs when supplements are used on natural pasture. If, for instance, a urea-containing supplement is able to correct a protein deficiency in natural pasture, the response will be very different than if the same amount of urea fed per day is used to replace natural protein in an intensive feedlot ration. In effect the nutritive value of feeds varies depending upon the nature of the other ingredients of the diet so that the extent to which one can be used to replace another is not constant. Under conditions where cultivated pastures, fodder crops, various by-products and compound feeds form the basis of beef cattle nutrition it is usually the energy content of

feeds rather than their protein content which principally determines their relative value. An exception to this would be in the nutrition of artificially-weaned young calves. Such practices are not however generally widespread as yet in developing countries and will not be considered further here.

The energy requirements of mature ruminants can be considered fairly simply employing the equation;

$$Mm = 8.3 + 0.091\ W$$

where Mm = the maintenance requirement in megajoules (MJ) of metabolisable energy (ME) and W = liveweight of the animal in kilogrammes.

Metabolisable energy is defined as the gross energy value of the feed minus energy lost in faeces, urine and as combustible gases from the rumen (one kilogramme (kg) of Starch Equivalent is equal to approximately 15.75 MJ of ME). Tables are available which contain data on the metabolisable energy content at maintenance of various feeds which has either been determined directly or calculated from digestible nutrients. Provided appetite limits are not exceeded, the diet required to meet energy needs for mature ruminants (but not growing/fattening beef animals) can be calculated assuming that one feed can replace another according to its metabolisable energy content. In ruminants there is a requirement for a minimum amount of long-fibre-containing roughage to maintain normal rumen motility and this should not normally be less than 20% of the total diet. In general calves suckle milk for many months in developing countries in what may be described as a cow/calf system. The milk which the cow provides to a calf may be only one or two litres per day and this can be allowed for in calculating cow energy requirements by adding 5 MJ ME for each litre of milk which it is predicted is consumed by the calf.

Probably the principal difficulty involved in formulating beef cattle rations is the estimation of the ME value of feeds, especially of the various grasses, straws and other cellulosic materials common in developing countries. In this regard the experience of trained nutritionists is particularly useful. Fortunately increasing quantities of information are becoming available on the energy value of these materials by using in vitro digestibility techniques to predict their energy value. A further difficulty is the differences in the quality of various sources of crude protein. Amino acid composition, digestibility and solubility of proteins in the rumen are factors receiving increasing attention and it is expected that improved systems for considering the protein requirements of ruminants will become

available over the next few years. Currently however the crude protein contents of feeds may be used as a basis for calculation with ad hoc modification of diets according to the differing characteristics of the nitrogenous fractions in the ingredients.

(D) Feedlots

Feedlots are for the intensive finishing of cattle to slaughter weight for beef. They are a major feature of the beef industry of the North American prairies and are sometimes considered for incorporation into beef projects in developing countries. The concept of the least-cost feed mix for finishing an animal, is highly relevant to this type of production unit. In North America it is a common practice to calculate rations by using linear programming techniques. Large commercial feed lots may well have their own computer and laboratory facilities in order to up date their feed mixes given variations in market prices, the seasonal availability of different feeds, variations both in the nutritive values of different feeds and in samples of the same type of feed.

The metabolisable energy content of a feed is measured on a dry matter basis as megajoules in a kilogram of dry matter, abbreviated to MJ/kgDM - this is known as the M/D value of the feedstuff. To calculate the amount of feed required by an animal in a feedlot reference can be made to Table 1. For example, a steer weighing 400kg in a feedlot being fed a ration with an M/D value of 12 MJ/kgDM is required to have a liveweight gain of 0.75 kg/day and therefore will require to have an ME intake of 72 MJ/day. Since the feedstuff contains 12 MJ/kgDM the steer will have a food requirement of $\frac{72}{12}$ = 6 kg of DM/day.

Table 1 is of no value however in the selection of feeds for growing/fattening beef animals on a least-cost basis, since the net energy value of a feed is dependent upon rate of liveweight gain of the animal and the weight of the animal as well as upon M/D value. One system in use is to determine the Animal Production Level (APL) of the animal according to the equation;

$$APL = 1 + \frac{(LWG\ (6.28 + 0.0188))}{((1-0.3\ LWG)\ (5.67 + 0.061W))}$$

where LWG = liveweight gain of the animal and W = the weight of the animal.

Using the APL value, net energy values (in MJ/kgDM), can be calculated for each feed using the equation;

$$NEmp = \frac{(MEF)^2 \times APL}{1.39\ MEF + 23(APL-1)}$$

where MEF is is the metabolisable energy value of the feed in MJ ME per kg dry matter.

APL and NEmp values are given in Tables 2 and 3. NEmp values can be used together with other parameters such as the ash, fibre, fat, calcium, phosphorus and protein contents of the feeds to determine least cost rations by linear programming.

It must be pointed out however that feed requirements and net energy estimates are based on research with steers in temperate climates, values for entire animals raised under tropical conditions may be different to some extent. Compensatory growth is a factor frequently determining the profitability of feedlot operations in developing countries and the figures presented do not take this into account. In practice therefore deviation will occur from theoretical predictions of feed requirements in Table 1.

TABLE 1

DAILY ME ALLOWANCES FOR GROWING AND FATTENING CATTLE
(MJ/head)

Liveweight (kg)	Ration M/D (MJ/kg)	Rate of gain (kg/day)						
		0	0.25	0.50	0.75	1.00	1.25	1.50
100	8	17	24					
	10	17	22	29				
	12	17	21	27	33			
	14	17	21	25	31	37		
150	8	22	29					
	10	22	28	35				
	12	22	27	33	40	48		
	14	22	26	31	37	44	53	
200	8	27	35					
	10	27	34	41	51			
	12	27	33	39	47	56		
	14	27	32	37	45	52	62	74
250	8	31	40	51				
	10	31	38	47	57			
	12	31	37	44	51	63	75	
	14	31	36	42	49	58	69	83
300	8	36	46	57				
	10	36	44	53	64			
	12	36	43	50	59	70	84	
	14	36	42	48	56	65	77	92
350	8	40	51	63				
	10	40	48	58	70	84		
	12	40	47	55	65	77	92	
	14	40	46	53	62	72	84	101
400	8	45	56	70				
	10	45	54	65	77	93		
	12	45	53	61	72	85	101	
	14	45	51	59	68	79	93	110
450	8	49	61	75				
	10	49	59	70	83			
	12	49	57	67	78	91	108	
	14	49	56	64	74	85	100	118
500	8	54	67	82				
	10	54	64	76	91			
	12	54	63	73	85	99	117	
	14	54	61	70	80	93	108	128
550	8	59	73	89				
	10	59	70	83	98			
	12	59	68	79	91	107	126	
	14	59	67	76	87	100	116	137
600	8	63	77	94				
	10	63	75	88	104			
	12	63	73	84	97	114	134	
	14	63	71	81	92	106	124	146

TABLE 2

ANIMAL PRODUCTION LEVEL

Live-weight Gain kg/day	LIVEWEIGHT kg												
	100	120	140	150	160	180	200	220	240	250	260	280	300
0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.05	1.04	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
0.10	1.07	1.07	1.06	1.06	1.06	1.06	1.06	1.06	1.05	1.05	1.05	1.05	1.05
0.15	1.11	1.10	1.10	1.10	1.09	1.09	1.09	1.09	1.08	1.08	1.08	1.08	1.08
0.20	1.15	1.14	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.11	1.11	1.11	1.11
0.25	1.19	1.18	1.17	1.17	1.16	1.16	1.15	1.15	1.14	1.14	1.14	1.14	1.13
0.30	1.23	1.22	1.21	1.20	1.20	1.19	1.19	1.18	1.18	1.17	1.17	1.17	1.16
0.35	1.27	1.26	1.25	1.24	1.24	1.23	1.22	1.21	1.21	1.21	1.20	1.20	1.19
0.40	1.32	1.30	1.29	1.28	1.27	1.26	1.26	1.25	1.24	1.24	1.24	1.23	1.23
0.45	1.36	1.34	1.33	1.32	1.31	1.30	1.29	1.28	1.28	1.27	1.27	1.26	1.26
0.50	1.41	1.39	1.37	1.36	1.35	1.34	1.33	1.32	1.31	1.31	1.31	1.30	1.29
0.55	1.46	1.43	1.41	1.40	1.40	1.38	1.37	1.36	1.35	1.35	1.34	1.33	1.33
0.60	1.51	1.48	1.46	1.45	1.44	1.42	1.41	1.40	1.39	1.38	1.38	1.37	1.36
0.65	1.56	1.53	1.51	1.50	1.49	1.47	1.45	1.44	1.43	1.42	1.42	1.41	1.40
0.70	1.61	1.58	1.56	1.54	1.53	1.51	1.50	1.48	1.47	1.47	1.46	1.45	1.44
0.75	1.67	1.64	1.61	1.59	1.58	1.56	1.54	1.53	1.51	1.51	1.50	1.49	1.48
0.80	1.73	1.69	1.66	1.65	1.63	1.61	1.59	1.57	1.56	1.55	1.55	1.53	1.52
0.85	1.79	1.75	1.72	1.70	1.69	1.66	1.64	1.62	1.61	1.60	1.59	1.58	1.57
0.90	1.85	1.81	1.77	1.76	1.74	1.72	1.69	1.67	1.66	1.65	1.64	1.63	1.61
0.95	1.92	1.87	1.83	1.82	1.80	1.77	1.75	1.72	1.71	1.70	1.69	1.67	1.66
1.00	1.99	1.94	1.90	1.88	1.86	1.83	1.80	1.78	1.76	1.75	1.74	1.72	1.71
1.05	–	2.01	1.96	1.94	1.92	1.89	1.86	1.84	1.81	1.80	1.80	1.78	1.76
1.10	–	–	2.03	2.01	1.99	1.95	1.92	1.90	1.87	1.86	1.85	1.83	1.82
1.15	–	–	–	–	2.06	2.02	1.99	1.96	1.93	1.92	1.91	1.89	1.87
1.20	–	–	–	–	–	2.09	2.05	2.02	2.00	1.98	1.97	1.95	1.93
1.25	–	–	–	–	–	–	2.12	2.09	2.06	2.05	2.04	2.01	1.99
1.30	–	–	–	–	–	–	–	2.16	2.13	2.12	2.11	2.08	2.06
1.35	–	–	–	–	–	–	–	–	2.21	2.19	2.18	2.15	2.13
1.40	–	–	–	–	–	–	–	–	–	–	2.25	2.22	2.20
1.45	–	–	–	–	–	–	–	–	–	–	–	2.30	2.28
1.50	–	–	–	–	–	–	–	–	–	–	–	–	2.36

TABLE 2

ANIMAL PRODUCTION LEVEL (continued)

Live-weight Gain kg/day	LIVEWEIGHT kg												
	300	320	340	350	360	380	400	420	440	450	460	480	500
0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
0.05	1.03	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
0.10	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.04
0.15	1.08	1.08	1.08	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
0.20	1.11	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.09	1.09	1.09	1.09
0.25	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.12	1.12	1.12	1.12
0.30	1.16	1.16	1.16	1.16	1.16	1.15	1.15	1.15	1.15	1.15	1.15	1.14	1.14
0.35	1.19	1.19	1.19	1.19	1.18	1.18	1.18	1.18	1.18	1.17	1.17	1.17	1.17
0.40	1.23	1.22	1.22	1.22	1.21	1.21	1.21	1.21	1.20	1.20	1.20	1.20	1.20
0.45	1.26	1.25	1.25	1.25	1.25	1.24	1.24	1.24	1.23	1.23	1.23	1.23	1.23
0.50	1.29	1.29	1.28	1.28	1.28	1.27	1.27	1.27	1.26	1.26	1.26	1.26	1.26
0.55	1.33	1.32	1.32	1.31	1.31	1.31	1.30	1.30	1.29	1.29	1.29	1.29	1.29
0.60	1.36	1.35	1.35	1.35	1.35	1.34	1.34	1.33	1.33	1.33	1.32	1.32	1.32
0.65	1.40	1.39	1.39	1.38	1.38	1.38	1.37	1.37	1.36	1.36	1.36	1.35	1.35
0.70	1.44	1.43	1.43	1.42	1.42	1.41	1.41	1.40	1.40	1.39	1.39	1.39	1.38
0.75	1.48	1.47	1.46	1.46	1.46	1.45	1.44	1.44	1.43	1.43	1.43	1.42	1.42
0.80	1.52	1.51	1.51	1.50	1.50	1.49	1.48	1.48	1.47	1.47	1.47	1.46	1.46
0.85	1.57	1.56	1.55	1.54	1.54	1.53	1.52	1.52	1.51	1.51	1.50	1.50	1.49
0.90	1.61	1.60	1.59	1.59	1.58	1.57	1.57	1.56	1.55	1.55	1.55	1.54	1.53
0.95	1.66	1.65	1.64	1.63	1.63	1.62	1.61	1.60	1.59	1.59	1.59	1.58	1.58
1.00	1.71	1.70	1.69	1.68	1.67	1.66	1.66	1.65	1.64	1.64	1.63	1.63	1.62
1.05	1.76	1.75	1.74	1.73	1.72	1.71	1.70	1.69	1.69	1.68	1.68	1.67	1.66
1.10	1.82	1.80	1.79	1.78	1.78	1.76	1.75	1.74	1.73	1.73	1.73	1.72	1.71
1.15	1.87	1.86	1.84	1.84	1.83	1.82	1.81	1.80	1.79	1.78	1.78	1.77	1.76
1.20	1.93	1.92	1.90	1.89	1.89	1.87	1.86	1.85	1.84	1.83	1.83	1.82	1.81
1.25	1.99	1.98	1.96	1.95	1.94	1.93	1.92	1.91	1.90	1.89	1.89	1.88	1.87
1.30	2.06	2.04	2.02	2.01	2.01	1.99	1.98	1.97	1.95	1.95	1.94	1.93	1.92
1.35	2.13	2.11	2.09	2.08	2.07	2.06	2.04	2.03	2.02	2.01	2.00	1.99	1.98
1.40	2.20	2.10	2.16	2.15	2.14	2.12	2.11	2.09	2.08	2.07	2.07	2.06	2.05
1.45	2.28	2.25	2.23	2.22	2.21	2.19	2.18	2.16	2.15	2.14	2.14	2.12	2.11
1.50	2.36	2.33	2.31	2.30	2.29	2.27	2.25	2.24	2.22	2.21	2.21	2.19	2.18

TABLE 3

NET ENERGY VALUES FOR MAINTENANCE & PRODUCTION NE mp (MJ/kg DM)

APL	ME OF FOOD, MEF (MJ/kg DM)												
	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0
1.00	3.6	4.0	4.3	4.7	5.0	5.4	5.8	6.1	6.5	6.8	7.2	7.6	7.9
1.10	3.0	3.3	3.7	4.1	4.5	4.9	5.2	5.6	6.0	6.4	6.8	7.2	7.6
1.15	2.8	3.1	3.5	3.9	4.3	4.7	5.1	5.4	5.8	6.2	6.6	7.0	7.4
1.20	2.6	3.0	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.1	6.5	6.9	7.3
1.25	2.5	2.8	3.2	3.6	4.0	4.3	4.7	5.1	5.5	6.0	6.4	6.8	7.[illegible]
1.30	2.3	2.7	3.1	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.7	7.1
1.35	2.3	2.6	3.0	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.2	6.6	7.0
1.40	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.8	5.2	5.6	6.1	6.5	6.9
1.45	2.1	2.4	2.8	3.2	3.5	3.9	4.3	4.7	5.1	5.6	6.0	6.4	6.8
1.50	2.0	2.4	2.7	3.1	3.5	3.8	4.2	4.6	5.1	5.5	5.9	6.3	6.8
1.55	2.0	2.3	2.7	3.0	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.3	6.7
1.60	1.9	2.3	2.6	3.0	3.3	3.7	4.1	4.5	4.9	5.3	5.8	6.2	6.7
1.65	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.7	6.2	6.6
1.70	1.8	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1	6.6
1.75	1.8	2.1	2.5	2.8	3.2	3.6	3.9	4.4	4.8	5.2	5.6	6.1	6.5
1.80	1.8	2.1	2.4	2.8	3.1	3.5	3.9	4.3	4.7	5.1	5.6	6.0	6.5
1.85	1.7	2.1	2.4	2.7	3.1	3.5	3.9	4.3	4.7	5.1	5.5	6.0	6.4
1.90	1.7	2.0	2.4	2.7	3.1	3.4	3.8	4.2	4.6	5.1	5.5	5.9	6.4
1.95	1.7	2.0	2.3	2.7	3.0	3.4	3.8	4.2	4.6	5.0	5.5	5.9	6.4
2.00	1.7	2.0	2.3	2.6	3.0	3.4	3.8	4.2	4.6	5.0	5.4	5.9	6.3
2.05	1.6	2.0	2.3	2.6	3.0	3.3	3.7	4.1	4.5	5.0	5.4	5.8	6.3
2.10	1.6	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.5	4.9	5.4	5.8	6.3
2.15	1.6	1.9	2.2	2.6	2.9	3.3	3.7	4.1	4.5	4.9	5.3	5.8	6.2
2.20	1.6	1.9	2.2	2.5	2.9	3.3	3.6	4.0	4.4	4.9	5.3	5.7	6.2
2.25	1.6	1.9	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.8	5.3	5.7	6.2
2.30	1.6	1.9	2.2	2.5	2.8	3.2	3.6	4.0	4.4	4.8	5.3	5.7	6.2
2.35	1.5	1.8	2.1	2.5	2.8	3.2	3.6	4.0	4.4	4.8	5.2	5.7	6.1
2.40	1.5	1.8	2.1	2.5	2.8	3.2	3.5	3.9	4.3	4.8	5.2	5.7	6.1
2.45	1.5	1.8	2.1	2.4	2.8	3.1	3.5	3.9	4.3	4.7	5.2	5.6	6.1
2.50	1.5	1.8	2.1	2.4	2.8	3.1	3.5	3.9	4.3	4.7	5.2	5.6	6.1

TABLE 3

NET ENERGY VALUES (continued)

APL	ME OF FOOD, MEF (MJ/kg DM)												
	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0
1.00	7.9	8.3	8.6	9.0	9.4	9.7	10.1	10.4	10.8	11.2	11.5	11.9	12.2
1.10	7.6	8.0	8.3	8.7	9.1	9.5	9.9	10.3	10.7	11.1	11.5	11.9	12.3
1.15	7.4	7.8	8.2	8.6	9.0	9.4	9.8	10.2	10.6	11.0	11.5	11.9	12.3
1.20	7.3	7.7	8.1	8.5	8.9	9.4	9.8	10.2	10.6	11.0	11.4	11.9	12.3
1.25	7.2	7.6	8.0	8.4	8.9	9.3	9.7	10.1	10.6	11.0	11.4	11.9	12.3
1.30	7.1	7.5	7.9	8.4	8.8	9.2	9.7	10.1	10.5	11.0	11.4	11.9	12.3
1.35	7.0	7.4	7.9	8.3	8.7	9.2	9.6	10.1	10.5	11.0	11.4	11.9	12.3
1.40	6.9	7.4	7.8	8.2	8.7	9.1	9.6	10.0	10.5	10.9	11.4	11.9	12.3
1.45	6.8	7.3	7.7	8.2	8.6	9.1	9.5	10.0	10.5	10.9	11.4	11.9	12.3
1.50	6.8	7.2	7.7	8.1	8.6	9.0	9.5	10.0	10.4	10.9	11.4	11.9	12.3
1.55	6.7	7.2	7.6	8.1	8.5	9.0	9.5	9.9	10.4	10.9	11.4	11.9	12.3
1.60	6.7	7.1	7.6	8.0	8.5	9.0	9.4	9.9	10.4	10.9	11.4	11.9	12.4
1.65	6.6	7.1	7.5	8.0	8.4	8.9	9.4	9.9	10.4	10.9	11.4	11.9	12.4
1.70	6.6	7.0	7.5	7.9	8.4	8.9	9.4	9.9	10.4	10.8	11.4	11.9	12.4
1.75	6.5	7.0	7.4	7.9	8.4	8.9	9.3	9.8	10.3	10.8	11.3	11.9	12.4
1.80	6.5	6.9	7.4	7.9	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.9	12.4
1.85	6.4	6.9	7.4	7.8	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.9	12.4
1.90	6.4	6.8	7.3	7.8	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.9	12.4
1.95	6.4	6.8	7.3	7.8	8.3	8.8	9.3	9.8	10.3	10.8	11.3	11.9	12.4
2.00	6.3	6.8	7.3	7.7	8.2	8.7	9.2	9.7	10.3	10.8	11.3	11.9	12.4
2.05	6.3	6.8	7.2	7.7	8.2	8.7	9.2	9.7	10.3	10.8	11.3	11.9	12.4
2.10	6.3	6.7	7.2	7.7	8.2	8.7	9.2	9.7	10.2	10.8	11.3	11.9	12.4
2.15	6.2	6.7	7.2	7.7	8.2	8.7	9.2	9.7	10.2	10.8	11.3	11.9	12.4
2.20	6.2	6.7	7.2	7.6	8.1	8.6	9.2	9.7	10.2	10.8	11.3	11.9	12.4
2.25	6.2	6.7	7.1	7.6	8.1	8.6	9.1	9.7	10.2	10.7	11.3	11.9	12.4
2.30	6.2	6.6	7.1	7.6	8.1	8.6	9.1	9.7	10.2	10.7	11.3	11.9	12.4
2.35	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.6	10.2	10.7	11.3	11.9	12.4
2.40	6.1	6.6	7.1	7.6	8.1	8.6	9.1	9.6	10.2	10.7	11.3	11.9	12.4
2.45	6.1	6.6	7.1	7.5	8.1	8.6	9.1	9.6	10.2	10.7	11.3	11.9	12.4
2.50	6.1	6.6	7.0	7.5	8.0	8.6	9.1	9.6	10.2	10.7	11.3	11.9	12.4

Appendix 7

TECHNICAL COEFFICIENTS

The choice of realistic technical coefficients is one of the most difficult problems facing the appraiser. He has to select coefficients for:-

a. The baseline situation

The situation at the beginning of the appraisal period.

b. The subsequent years after the new investment has been made. The incremental returns to the new investment may depend on the achievement of a major improvement in the level of technical coefficients.

The Baseline Situation

The lowest levels of technical coefficients may well be returned by the pastoral sector of an African country. To quote an Ethiopian example*:-

> "It has been estimated that over 50% of the annual calf crop does not reach maturity. Total off-take for commercial slaughter is certainly below 5% of the total herd"...."Stock reach slaughter point in poor condition. Cattle with a skeleton frame that could carry 350 kg of body weight, on average weigh 280 kg with a yield of only 90 kg of meat-without-bone."

To quote another African example to give some impression of coefficients obtained at the other end of the productivity scale, figures are taken from a Kenyan study(41). These refer to the baseline situation on a commercial ranch before the new investment takes place. As in Ethiopia, the cattle depend almost entirely on natural grazing. In the Kenyan example, the effective calving rate is 75% (75 calves per 100 cows, survive to weaning) and rather less than 4% of the calves which reach weaning age, die before maturity. Fat steers are sold at 3 years old with a liveweight averaging around 480 Kgs with a 55% killing out percentage.

Feed lots for the intensive fattening of cattle may well be non-existent in many developing countries, so it could well be impossible to obtain local baseline data. The best the appraiser can do is to take local expert opinion in relating figures from other countries to any local project.

* Imperial Ethiopian Government, Livestock and Meat Board, "Livestock (and Products) Marketing Report, 1971"(pages 9 and 11).

Improvements in the Levels of Technical Coefficients to be achieved by the New Investment

Where information is available locally on the results obtained from the introduction of new practices, the appraiser has then to consider whether it is realistic to assume that these improvements could be achieved within a given period of years in his particular project. Where such information is not available, then one approach is first to test for the sensitivity of the individual technical coefficient and if indeed it is sensitive, then either calculate the appraisal taking a low, medium and high level of technical performance respectively in the sensitive variable or carry out a risk analysis, putting the value of the technical coefficient at risk.

The Tables

The tables which follow give examples of baseline coefficients and assumed levels of improvements in these coefficients which will result from the new investment. The data has been extracted from a series of recent appraisal reports mostly published since 1969. While the baseline figures are probably realistic, the projected improvements should be interpreted with caution, since as these projects have only been implemented recently, there is no evidence that the expected levels have been attained.

Finally these figures should not be used blindly in any appraisal exercise, use local figures if available.

Tables A1 and A3 give demographic coefficients for grazing projects in Africa and South America respectively while Tables A2 and A4 give productivity coefficients. It will be seen that little information is available on liveweights at slaughter and killing out percentages. Also no data are given for feed lots. So the following notes are included to help cover the gaps.

Notes on Weights and Killing out Percentages.

The following figures are based on slaughter house returns.

a. Somalia 1972

The average liveweight of cattle purchased by the government's meat canning factory was 242 kg with a killing out percentage of 44% giving 106 kg of carcase dressed weight (C.D.W). The cattle concerned came largely from nomadic producers.

A) AFRICA

TABLE A 1

DEMOGRAPHIC COEFFICIENTS - GRAZING PROJECTS (1)

Country and Date	Values in Year 1		Final Improved Values		No of Years to reach improved values
	Calving Rate (2)	Annual Death Rate (3)	Calving Rate (2)	Annual Death Rate (3)	
	%	%	%	%	
Ranching Schemes					
Nigeria 1974					
State ranches	50	3	75	2	8
Private ranches	50	3	80	2	8
Ghana 1974					
State ranches	60-65	2-3	70-75	2	5
Private ranches	48	3-4	60	3	5
Kenya 1974					
Company ranches	50	5	70	4	5
Group ranches (4)	55	5	65	4	5
Congo: (Brazzaville 1973)					
State ranches	65	1	80	1	8
Range Improvement and Village Herd Schemes					
Ethiopia 1974	56	13	60	6	5
Sudan 1975	60	5	60	5	-
Madagascar 1974	50	6	55	4	5

NOTES

(1) Source: appraisal reports.
(2) Effective calving rate (calves surviving to weaning, per 100 cows).
(3) All classes except calves.
(4) For settlement of nomads and their cattle

TABLE A 2

PRODUCTIVITY COEFFICIENTS - GRAZING PROJECTS (1)

Country and Date	Values in Year 1			Final Improved Values			
	Carrying Capacity (2)	Fat Steers Age at Sale (years)	Fat Steers Liveweight at Sale (Kgs)	Carrying Capacity (2)	Fat Steers Age at Sale (years)	Fat Steers Liveweight at Sale (Kgs)	No. of Years to reach Improved Values
Ranching Schemes							
Nigeria 1974							
State ranches	0.4	4	n.a.	3.0	3	n.a.	5 8[3]
Private ranches	0.4	4	n.a.	2.0	3	n.a.	5-8[3]
Ghana 1974							
State ranches	0.5	4	n.a.	1.0	3	n.a.	5
Private ranches	n.a.	5	n.a.	n.a.	4	n.a.	5
Kenya 1974							
Company ranches	0.2	4-5	n.a.	0.4	3-4	n.a.	5
Group ranches (4)	0.7	4-5	n.a.	0.9	3-4	n.a.	5
Congo (Brazzaville 1973)							
State ranches	0.4	3-4	300-350	3.2	3-4	300-350	0-8[(5)]
Range Improvement and Village Herd Schemes							
Ethiopia 1974	n.a.	4	230	n.a.	3	260	5-10[(6)]
Madagascar 1974	n.a.	6-7	340	n.a.	5-6	370	5

n.a. = not available

NOTES

(1) Source as Table A1 (No details available for killing out percentages).
(2) Carrying capacity - Animal Units per 10 acres.
(3) 5 years for sale age reduction, 8 years for improvement in carrying capacity.
(4) Group ranches are for the settlement of nomads.
(5) Only improvement overtime is carrying capacity.
(6) 5 years for sale age reduction, 10 years for liveweight improvement.

B) SOUTH AMERICA

TABLE A 3

DEMOGRAPHIC COEFFICIENTS - GRAZING PROJECTS (1)

Country and Date	Values in Year 1		Final Improved Values		No. of Years to reach Improved Values
	Calving Rate (2)	Annual Death Rate (3)	Calving Rate (2)	Annual Death Rate (3)	
	%	%	%	%	
Ranches					
Uruguay 1970 (4)					
Existing ranches	65	4	70	4	5
New ranches	55	5	65	3	5
Ecuador 1971	60	3-6	75	2-3	5
Paraguay 1979	50	3	62	2	5

NOTES

(1) Source appraisal reports
(2) Effective calving rate (calves surviving to weaning per 100 cows)
(3) All classes except calves
(4) Appraisal covers both improvements to existing ranches and new ranches.

TABLE A 4

PRODUCTIVITY COEFFICIENTS - GRAZING PROJECTS (1)

Country and Date	Values in Year 1		Final Improved Values		No. of Years to reach Improved Values
	Carrying Capacity (2)	Sale Age Fat Steers (Years)	Carrying Capacity (2)	Sale Age Fat Steers (Years)	
Ranches					
Uruguay 1970					
Existing ranches	3.5	3	3.6	2	5
New ranches	2.8	4	2.9	3	5
Ecuador 1971	4.8	3-4	7.6	2-3	5

NOTES

(1) Source appraisal reports. No information given on liveweights or killing out percentages.
(2) Carrying capacity - Animal Units per 10 acres.

b. Kenya 1968

These returns of the Kenya Meat Commission show the contrast between the C.D.W. weights of cattle from nomadic producers and those from commercial ranchers.

Cattle bought from commercial ranches in the Nakuru area returned an average of 145 kg C.D.W. while cattle bought from predominantly Masai nomad sources averaged only 108 kg C.D.W.

Other Kenya figures suggest that under local conditions, cattle at full skeleton size gain, on average, one percentage unit in killing out percentage for every 15-18 kg of liveweight increase.

Feed lots

The appraiser here is concerned with estimating the desired total liveweight gain required to attain a satisfactory killing-out percentage and liveweight at slaughter (these are correlated), and the least-cost food mix to attain the desired weight gain. Methods of estimating the least-cost food mix are discussed in Appendix 6. Liveweight gains under experimental conditions may be published locally; consult local experts.

Of interest is the work of Newbery in Kenya on feed lots (35).
He shows that local cattle averaged liveweight gains of 0.82 to 1.38 kg a day according to the type of ration fed and the initial size of the animal.

Water requirements for cattle

Theoretical requirements for the different age and sex groups of cattle are given in standard text books (I). A broad working estimate used by a British consultancy firm suggests a daily requirement of 4 gallons a day per head for all cattle including calves. This estimate is based on surveys made among nomad producers in the Western Sudan.

P[illegible]lopment Revenue from Traditional Pastoral Systems

This refers to the value of the output of the land before development.
An unpublished UNDP/FAO Kenyan survey of masai nomads estimates the annual output per acre in terms of 4 lbs of meat liveweight. A Sudanese estimate of output from land used by nomads puts the value of this at LS.0.85,* including meat, wood, charcoal and gum Arabic. The Kenyan estimate refers to an area with an average rainfall of 500-600 mms. The Sudanese figure is based on conditions of rather wetter land; 700-800 mms annual rainfall range (40).

* Say, approximately £1 sterling. The figure refers to 1974.

Appendix 8

THE CALCULATION OF A DISCOUNT FACTOR

A discount rate is the weight by which a future income, cost or net cash flow is multiplied by to obtain its present value.

The general formula used here is:-

$$\frac{1}{(1 + d)^{n-1}}$$

where n is the year of the project's life, whose future income, cost and net cash flows are being discounted.*

d is the discount rate expressed as a decimal,
so that the value of (1 + d) with a 10% rate = 1.10, with a $7\frac{1}{4}$% rate = 1.0725.

With reference to the discount factors given in Table 10, column 5, these are calculated as follows:-

(Year 1 is not discounted)

Year	Value of $(1 + d)^{n-1}$ (10% discount rate)	Value of $\frac{1}{(1 + d)^{n-1}}$ (The discount factor)
2	1.10	0.9091
3	1.21	0.8264
4	1.331	0.7513
12	2.8531	0.3505

* This assumes that the first year streams are not discounted so that in the 2nd year the value of $(1 + 0.10)^1 = 1.10$, the 3rd year value is $(1 + 0.10)^2 = 1.21$, and so on.

If it is decided to discount the 1st year streams then the formula is:-

$$\frac{1}{(1 + d)^n}$$

Appendix 9

SENSITIVITY ANALYSIS - A SHORT CUT METHOD FOR EXAMINING THE SENSITIVITY OF FINANCIAL COEFFICIENTS

Financial coefficients are used to price the inputs and outputs of "a given production mix", consequently if the mix remains the same* and all other factors are kept constant, it is very easy to calculate the effect of changes in the value of one financial coefficient on the size of the net present value, since the effect is linear. For example a 1% change in the sale price of fat cattle will result in a constant absolute rate of change in the value of the net present value. Consequently the percentage change in the value of the coefficient required to reduce the net present value to zero at a given rate of discount corresponding to the rate of interest charged to the borrower (the "cut off point" of the investment) can be calculated. This is repeated for each of the major financial coefficients and the results can then be ranked in order of magnitude to give their relative sensitivities.

For example:-

If the net present value of a ranch investment is +£15,000 at a 10% discount rate (10% is the current rate of interest for loans), and every 1% fall in the sale price of fat cattle reduces the net present rate by £1,000, then the percentage fall in the sale price necessary to reduce the net present value to zero (the cut off point at 10%) is:-

$$\frac{15,000}{1,000} \text{ or } 15\%$$

[all other factors remaining constant]

A Kenyan example (41) ranks the major coefficients in order of the percentage increase or decrease in their values required to reach the cut-off point at 10% discount rate.

Water installation costs	+ 413%
Annual fixed and variable costs	+ 99%
Cattle purchase prices	+ 36%
Cattle sale prices	- 15%

This ranking gives a clear indication of relative sensitivities in a given situation. The magnitude of these percentages of course should not be used in other projections, only the method by which they were obtained.

* Changes in the value of biological coefficients (birth and death rates) effect the composition of the "production mix" so have a non-linear effect on the size of the net present value.

Appendix 10

RISK ANALYSIS - WEIGHTING OF TECHNICAL AND FINANCIAL COEFFICIENTS

Instead of taking one unique value for a given coefficient, the appraiser takes a range of possible values and selects appropriate weights according to the type of probability distribution he believes to pertain.

For example instead of taking £30 as the sale price for a fat steer, he uses instead a range of values from £25 to £35 and selects appropriate weights. He believes that there is an equal chance of the price rising above or falling below £30 and that the probability of higher or lower price change diminishes as one moves away from the mean (£30).

So he weights his prices as follows:-

Price per Head (£s)	Probabilities (%)
25	1
26	2
27	3
28	4
29	15
30	50
31	15
32	4
33	3
34	2
35	1
	100

ie There is a 50% chance that the price will be £30 and a 1% chance respectively that the price will be £25 or £35. For further details see (24).

Appendix 11

THE PROVISION OF WATER FOR LIVESTOCK DEVELOPMENT (WITH SPECIAL REFERENCE TO AFRICA)

The Importance of Water

The highly seasonal character of rainfall and its uneven distribution give rise to competition for available surface and sub-soil water between agriculturalist and pastoralist. In terms of total grazing, the well-watered areas in the vicinity of the main rivers and their perennial tributaries, and around springs and areas of seepage are relatively limited. Notwithstanding ancient and modern methods of supplementing inadequate surface water by tapping subsoil and underground sources, in the more favoured areas the competition for available land and water for cultivation and settlement, in conjunction with excessive concentration of oxen and other livestock, has often led to the virtual destruction of pasture. In such cases, the problem is one of extending water supplies to areas where there is grazing and then preserving the grazing itself. The two are in fact inseparable. As has been observed in parts of the West African Sahelian zone, for six months of the year owners of livestock are frequently faced with the choice of either concentrating their animals round a water hole where they may die of hunger or keeping them on the waterless pastures where they will die of thirst. Hence the long migrations in search of both food and water.

The water requirements of livestock vary according to age, breed, nutritional level, utilisation, temperature and humidity. Furthermore, if the moisture content of pasture (and browse) is high, as it may be for a few months during the rainy season, sheep and goats will require little or no drinking water and cattle requirements may be reduced to half. Ability to survive periods without water increases from cattle, sheep, goats and camels - in that order; hence the importance of fat-tailed sheep, goats and camels in the nomadic North and West. Experiments have shown a high tolerance among indigenous cattle to doing without water for two or three days at a time, but this appears to be linked with a lower plane of nutrition. In planning water requirements it is probably unwise to accept any general reduction in the standards hitherto accepted, eg an average of 7-10 gallons (26-38 litres) per day for cattle and $\frac{1}{4}$ - $\frac{1}{2}$ gallon for sheep and goats.

Planning Water Supplies

Two extreme types of situation give rise to the need for improved water supplies in extensive grazing areas. The first and less likely is where low productivity in existing herds is primarily attributable to the shortage of water, seasonal or chronic; the second where otherwise productive grazing cannot be opened up because water is either inadequate or virtually non-existent for most of the year. Between these extremes there are situations where both features arise. In many cases, the provision of water in an unused grazing area may be an alternative to the improvement of facilities in a neighbouring one that is overstocked in relation to grazing and water. In others, it is the distribution of watering points in relation to the carrying capacity of the grazing rather than the overall lack of water that commands attention. In general, there are few areas where there is a satisfactory distribution of watering points, bearing in mind that cattle can graze within a radius of up to twelve miles from their water supply.

Types of Facilities

The various alternatives for water supply comprise:-

Boreholes:	generally deeper than wells and powered by wind, animals or internal combustion engines. Capital costs greater in relation to recurrent costs than in the case of wells but unit costs lower;
Wells:	traditional and generally susceptible of construction by local communities with a minimum of technical assistance and capital; usually operated by human or animal power but may be adapted to wind or engine;
Hafirs: (Ballehs)	higher unit costs. Generally confined to areas of lower rainfall where impervious strata is close to the surface and run-off is high and markedly seasonal;
Dams:	very widely used under the same soil conditions as Hafirs but where rainfall is adequate to offset losses through evaporation;

Hydrams: little used in communal grazing areas even where sufficient head of water is available, as a result of the high cost of piping in relation to that of walking stock to the source of supply;

Other: improvement of natural watering points - springs (artesian wells), sponges and perennial rivers and streams; ponds.

Boreholes

Except in areas where impervious strata are very close to the surface, or in geological formations such as the basement complex of East Africa where yields from boreholes and wells are mediocre to negligible, the main scope for the increased provision of well-distributed water points in the drier pastoral country lies in boreholes (tubewells). The main component of cost, even where geophysical survey has been carried out thoroughly, is in boring and casing. Costs per foot increase with depth and strata encountered. In Botswana yields of 200 - 300 gallons per hour, and in Zimbabwe 600 - 1,000 gallons per hour are regarded as exploitable. Allowing for pumping to two-thirds capacity for an eight to twelve hour day, this provides water for 400 to 500 head of cattle which, in relation to carrying capacity of one head of large stock to 15 or 20 acres, is the optimum herd for any one watering point since cattle will not effectively graze beyond two or three miles of a watering point so long as there is grass remaining within that radius, unless they are herded.

Capital costs should allow for a storage tank and watering trough. Depending upon the standard of supervision and maintenance, and the availability of alternative facilities in case of breakdown, a week's storage capacity is usually adequate.

In central Africa frequent breakdowns have often led to the substitution of hand and animal operated equipment in place of engine power for small boreholes and wells. The capital cost of wind-powered boreholes is not significantly different from engine-powered ones, but operating costs and hence the unit cost of water is much lower. On the other hand, if appreciable storage is necessary as a result of a high incidence of windless days, the advantage may be reversed. For these reasons the possibility of utilising wind power should always be considered, but a decision will depend primarily upon local conditions.

Wells

In the case of wells, animal or human power - the traditional source - has the great advantage of simplicity, and saving of capital. Where labour is plentiful and water scarce, it also has the advantage that little is wasted and there is no problem of apportioning running costs - livestock owners merely drawing what they require for their own stock. However, unless organised lifting and adequate storage is provided on a communal basis, the number of stock that can be watered at a well will be limited by the time taken by individuals to draw water for their own herds. Where recharge is slow this may reduce the danger of drying out, but there may also be a tendency for animals to go short of water or to spend time around the well when they should be grazing. Sometimes social conflicts can arise between cultivators and pastoralists over water rights.

Hafirs

The cost of hafirs, both machine and hand excavated, has been worked out by various authorities. Relying upon a single or short-season recharge which must suffice for the next eight or nine months, storage per head of stock is high and hafirs are generally associated with domestic requirements and the needs of village flocks and herds rather than livestock in remoter grazing areas.

Dams

The capital cost of dam storage varies considerably according to topography, soil and size. Of the total stored, only about 50% will be available and of this not more than half will be generally used. The unit cost of water utilised will therefore be high. Given adequate control of catchment grazing, maintenance costs will be negligible, so that if capital charges (depreciation and interest) are offset against conservation programmes as is often the case in these areas, the problem of financing recurrent expenditure of any sort does not arise. The opportunities for communal construction of small dams in populous village areas are considerable but, in the extensive grazing country, sufficient labour is seldom available and the organisation of group activity is complicated by dispersal. Generally, therefore, small community dams are concentrated in the more densely settled areas or on the fringes of the grazings. Professional engineering expertise in dam design and construction will be necessary.

In the case of dams (and natural ponds, improved or otherwise), even where the subsoil is conducive to a high degree of retention, water losses through evaporation are in the region of 60" to 80" per annum, rising to 100" or more in the arid areas north of the Equator. The development of evaporation control through mono-molecular film may eventually provide a satisfactory answer, but at present a high order of supervision to maintain constant replacement of the film is impracticable in remoter areas, and this type of storage is generally limited to zones where topography and climate provide adequate run-off to offset such large evaporation losses.

It is also particularly necessary to control the access of large numbers of stock to the dam site itself and to its catchment. Unless the latter is protected from overgrazing, to the usual danger of pasture destruction from undue concentration around watering points will be added that of surface erosion in the catchment area, and silting of the dam. Ideally, a dam should not be used throughout the year unless water is taken off some distance away as the effects of continuous grazing and trampling will almost inevitably destroy the grass cover in the vicinity if optimum use is to be made of the water available. Provision should be made for stockowners to have access to uncontaminated water for their own consumption.

Other sources

Sometimes, considerable improvements can be made to facilities for watering at rivers and other perennial water courses, occasionally in seasonal "sandrivers". In many areas, eg Nigeria, considerable effort is being made to clear such places of tsetse. In common with most low-lying areas, including the fringes of dams and sponges, and in the vicinity of much-frequented springs, liver fluke and other internal parasites have to be guarded against. In general, the more salubrious areas for man and beast are occupied by cultivators but in all such cases the utilisation of water for livestock requires coordination.

Available spring water is generally utilised to meet human needs, but enclosure of the eye and piped lead-off to a storage tank at a cost of a few hundred pounds, will enable any surplus there is to be used for livestock. However, depending upon the nature of the recharge, steps must again be taken to protect the surrounding area from overgrazing.

Local participation

The participation of local authorities and communities in the clearing of sites and the construction of watering points is valuable where underemployment is common, since it reduces capital costs. It also gives beneficiaries an added incentive to maintain the facilities. It is in fact with the maintenance of the installations themselves and the regulation of their use, and that of the surrounding grazing, that local responsibility is most important as is recognised in the Freedom from Hunger campaign for the provision of watering facilities.

There can be no doubt of the need for national or regional planning for the survey, regulation and registration of groundwater development if future needs are to be safeguarded and present disputes and wasted effort are to be reduced. Even the storage of surface water generally demands some degree of coordination and skills not possessed by many pastoralists, if it is to be effectively utilised without posing conservation risks. Local authority participation in maintenance generally and in the construction of smaller installations is desirable, but in extensive grazing areas pastoralists are generally slow to take part in local government and the agriculturalist and villager may not be able or willing to provide anything like adequate funds for facilities from which they do not directly benefit.

In general, therefore, some degree of national or regional subsidisation is necessary. It is important, however, that beneficiaries should contribute some part of the operating costs and maintenance of the facilities provided since resources that are provided free are usually wasted. This applies even where communities have assisted with their construction for, unless they are prepared to impose some charge themselves, there will be a tendency for some users at least to think that they can do what they like with the installations they have helped to create, regardless of the consequences.

The easiest method of collecting financial contributions from beneficiaries, ie through levies of stock and produce sold through recognised marketing channels, is not the best. The most serious criticism in so far as the sale of livestock is concerned is that it reduces the price incentive at the point where it is most needed and bears most heavily upon those who have striven to increase take-off

from their herds. There is, moreover, no direct connection in the minds of livestock producers between the funds derived and the capital and recurrent costs of the facilities provided.

In the case of stock routes, charges can reasonably be made at strategic watering points to cover part or all of the cost of water, fencing and possibly the grazing utilised en route. In the case of nomadic and settled herds, an annual grazing and watering tax can be levied at periodic and convenient intervals. Some avoidance of tax is inevitable but if watering facilities are conditional on local contributions and this is made clear to individuals through local authorities and traditional leaders, these institutions may exert considerable influence on the willingness to pay.