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Economics of Livestock Disease Control

Economics is a social science dealing with the production and distribution of goods and hence of wealth. It analyses how scarce resources are allocated between different uses and groups within the economy. Originally, economic thought was developed under the name "political economy" and examined the production and distribution of wealth in a society composed of landlords, peasants and artisans With the advent of industrialisation, thinkers looked at the economic relationship between capitalists, workers and landlords. This approach was the one taken by Marx and underlies Marxist economics. Modern economies in the "capitalist" societies looks at the economic interactions between producers and consumers, who meet in the market place and try to satisfy their needs. Its aim is to analyst objectively the "positive" i.e. the verifiable or factual aspects of the economic relationships in society, and thus to derive generally applicable theories. It does not concern itself directly with the "normative" aspects which relate to value judgements about how the economic process ought to function.

The study of economics is conventionally divided into two areas. *Micro-economics* analyses the behaviour of individual producers and consumers, focusing on the factors influencing their levels of production and consumption and the mix of goods involved. *Macro-economics* analyses the economy as a whole, and deals with such topics as national income, balance of payments, overall savings and investment.

Development economics has emerged as a branch dealing with the specific problems of the less developed countries. It tries to analyse and explain the particular situation of these countries and to examine economic policies, such as price control, subsidies and taxes, and the channelling of investment funds into certain areas, which can help overcome their problems and improve their people's standard of living. The topics covered include an analysis of the causes and symptoms of poverty, of the dichotomy between the agricultural and the industrial sector in Third World countries, and of the extent of the bias in actual development towards urban areas. Development economics examines the questions of choice of technology, unemployment and underemployment,

migration and land reform, from an economic point of view and also studies the roles of trade and commodity markets.

Project appraisal, the economic analysis of projects before they are undertaken, and *project evaluation,* the assessment of projects after they have been undertaken, are practical applications of economic principles to decision-making based on a social benefit-cost analysis. This consists of setting out costs and benefits over a number of years and comparing them according to certain prescribed conventions so as to determine whether the project would be profitable. Budgeting and accounting are also techniques of applied economics.

APPLICATION OF ECONOMICS DISEASE CONTROL POLICY

Economics contributes to the improvement of policy formulation and decision-making for animal health projects and programmes at four levels:

- Economic theory explains the behaviour of producers and consumers, and the effect of this on the price structure and on the output of the economy as a whole. In the livestock sector, it explains how economic factors influence producers, how they decide what and how much to produce, what prices are acceptable to them, why production is expanded or contracted, how much they invest etc. It also explains the economic factors underlying demand for livestock products, how these affect the amount and mix of products bought, and how prices are fixed in different circumstances. The economic aspects of the different livestock production systems can be described by collecting relevant information and using it as well as the knowledge derived from economic theory to analyse how producers and consumers interact. A particular livestock production system can be described in economic terms by looking at the value of output, the cost of the inputs, calculating the income received by the producers, butchers, traders and other middlemen, and examining the final price paid by the consumers.
- Having characterised the production systems involved, as well as the interactions between the consumers and producers, it becomes possible to examine and predict the likely economic effects of any changes introduced into the sector. Such changes would include both changes affecting prices of inputs or outputs, which would affect the incomes of consumers and, therefore, demand, and changes in the technical coefficients of output due to introducing improved inputs, changing the animal health picture etc.
- Finally, the techniques of economic analysis make it possible to arrange this information so as to provide the basic yardsticks for ranking and hence comparing different programmes, projects or measures, and assessing their overall economic feasibility.

Thus, for an animal health project, economic theory can help explain producers' behaviour, describe the production systems involved, then help to predict and quantify the effect of the project on output, prices, demand and incomes, and, finally, provide a framework for arranging this information in the form of a *benefit-cost* analysis. Then, having ranked and compared the alternatives, a decision can be made whether to implement the project or not.

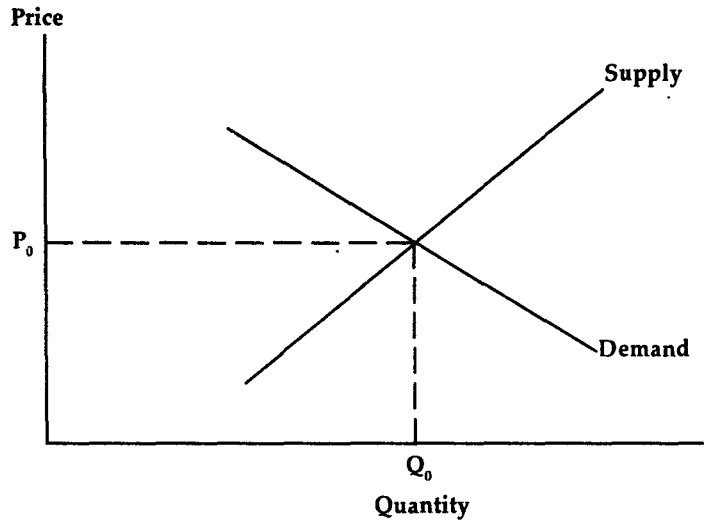
Obviously, decisions cannot be taken on the basis of economic considerations alone. First, the technical feasibility of any proposed measure must be examined by the relevant specialists. Second, its overall compatibility with the stated policies and goals of the livestock sector must be ensured, and, third, its feasibility from an organisational and social point of view needs to be verified.

PRICES APPROPRIATE FOR USE IN ECONOMIC ANALYSES

Prices are the "labels" or weights used in economic decision-making. As such, an understanding of how they are derived and what they represent is crucial. Money is the "unit" in terms of which prices of goods are given in a cash economy, although barter can fix their relative values. For example, if a kilogram of meat costs US$ 3 and a yard of cloth US$ 1.50, 2 yards of cloth could be exchanged for 1 kg of meat in the absence of money, or both could be paid for in cowries, manillas or some other acceptable currency.

Historically, price theory began with the concept of goods having either a scarcity value or a value because of the labour needed to produce them. Modern economies sees prices as being determined by the interaction of supply and demand, reflecting both the balance of the price producers are willing to accept, taking into account their production costs, and the price consumers are willing to pay for a certain quantity of goods. For most goods, the quantity offered increases with increasing price, but the quantity demanded decreases.

If supply equals demand, the market is said to be "in equilibrium" at price P_0. This price is also referred to as the *market-clearing* price, and it represents the point at which all that is offered is bought. At a higher price, supply exceeds demand, since producers are willing to offer more and consumers are reluctant to purchase. The converse is true if the price is lower than the market-clearing price, in which case consumers are eager to buy but producers are reluctant to sell or produce, and, consequently, the quantity demanded exceeds that supplied. If the individuals were bargaining in a real market place, they would continue to offer each other prices until they arrived at a mutually agreeable price, or else the consumer would decide not to buy or the producer not to sell.



Example: Suppose that a government fixes a maximum price for meat with the objective of ensuring that low-income consumers can afford the commodity. If this price is below the market-clearing price, producers would like to charge more, demand outstrips supply, and a black market develops where meat is sold at prices nearer to, or even exceeding, the market-clearing price to those consumers who can afford it. Conversely, if a government fixes a minimum price which is above the market-clearing price, supply will tend to outstrip demand at that price and suppliers will be forced to sell off their goods cheaply, avoiding the government regulations. This commonly happens when there is a fixed minimum wage for labour: if many people are looking for employment, a large number will end up accepting jobs below the minimum wage.

In fact, if a government wants its price-setting policies to be effective, it will often need to pay a subsidy to compensate producers, if the price is too low, or consumers, if it is too high. The government would need sufficient knowledge of the supply and demand curves for the product, i.e. the lines illustrating what quantity is demanded or supplied at which price, in order to work out at what price (P_1) the quantity supplied would be equal to that demanded at a minimum price (P_2) and representing the amount the government would like people to consume. The government can then pay producers a subsidy equivalent to the difference between P_1 and P_2, so that the supply rises to the level equal to the quantity demanded at the minimum price, and the market clears.

The discussion of price theory has raised several points which need to be considered when deciding which prices to use in various economic studies. These can be summarised as follows:

— Since for most goods the quantity demanded falls as the price rises, governments can stimulate demand for an item by setting a low price. Conversely, they can lower

demand by setting a high price. A low price can be supported by a subsidy, a high price may be enforced by a purchase tax. For example, the consumption of milk may be encouraged by setting a low price for consumers, backed up by a subsidy to producers. Similarly, new inputs into production systems, such as fertilisers, improved breeds of liverstock, ploughs etc, may be encouraged by subsidising their cost to whoever is prepared to use them. In the absence of a support for artificially high or low prices, black markets tend to emerge.

- Different consumers may pay different prices for the same goods. For example, because of the costs of transport, goods may cost more in isolated rural areas or if they are imported from another region or country. Products may be more expensive when bought in retail outlets with high overheads, while items sold in large quantities are usually cheaper. If a good passes through many hands before it is sold to the final consumer, it will be more expensive since every middleman on the way expects to make some profit. These are all concrete reasons for price variations.
- A more subtle effect is that of the individual consumer's bargaining power. In the market, one person may be better or worse at negotiating a price than another. On a wider scale, the price an individual will pay may depend on such things as his or her influence in society, whether the seller wishes to gain favour, or considers the purchaser rich and capable of paying a good price. All these effects are intensified in a black market.
- A variety of prices exists for each item affected by a government subsidy or tax. These include:
  - The price paid by the consumer, which may include a purchase tax or is the portion of the cost after the subsidy has been removed.
  - The price received by the producer, which is the price before purchase tax is added or, in the case of a subsidy, the equivalent to the price paid by the consumer plus the government subsidy.
  - The cost to the government of the subsidy or the revenue brought in by the tax.
  - The cost to the nation, which is roughly equivalent to the price paid to the producer. A government tax or subsidy is a transfer between tax payers who pay the subsidy or tax and those who benefit from it, either by receiving the subsidy or using the facilities financed with the money collected from the tax.

Prices of Factors of Production

So far we have analysed prices as though they were for consumer goods that were purchased outright. Prices for durable goods and the various inputs of production are slightly more complex. There are three factors of production to be considered:

- Labour, which can be divided into various grades;
- Land, which includes natural resources; and
- Capital, which covers both money itself and production goods such as livestock and machinery.

A fourth factor, entrepreneurship or management, is sometimes added to cover management and risk taking.

The factors of production are subject to the laws of supply and demand in the same way as other goods, but the demand for them is described as *derived demand*, since it depends on the demand for the products the factors are used to make. Given sufficient information about the production conditions, prices and the demand for final products, input-output models can be constructed for the whole economy to determine the demand for the different factors of production.

The many inputs of production and most durable goods can usually be bought in two ways:

- Outright purchase, which confers on the owner all the incomes that can be earned from using a particular input or all the benefits from a particular durable good.
- Renting or hiring, which enables the purchaser to use the item for a stated period of time.

Thus a durable consumer good, such as a television, can be owned or rented. Machines used for production can be hired or owned. Labour is usually rented out by an individual by the hour or week against a fixed wage. Capital in the sense of machinery and buildings can be owned or rented. Money in the sense of cash can either be owned, in which case the owner reaps the income it can earn, or rented in return for a payment per unit of the time that it is used. This "rental" is conventionally referred to as borrowing and the payment per unit of time is the interest. Similarly, land or mineral rights can be owned or rented for a period of time.

Underlying all investment or project appraisals is the concept that the various inputs or factors of production at the disposal of an individual or a nation should be used so as to earn that individual or nation the highest possible income. Thus, just as an individual should not borrow money at an interest of 10% per annum to finance an investment from which he expects a profit of 8% per annum, a nation should not invest resources in projects with a return of 8% when alternatives yielding 10% exist.

Choice of Prices in Economic Analysis

In a project appraisal or budget, the main economic input lies in the choice of prices, since it is assumed that the technical inputs which give the main physical components

of costs and benefits have been derived by the professionals responsible for ensuring the technical feasibility of the project. In the same way as all the assumptions necessary for deriving the physical parameters must be clearly stated, so the *origin* or *derivation* of every price or group of prices chosen must be given as well as *the justification* for using them. A simple rule determining which prices can be used in a particular analysis is that the prices chosen should approximate, as far as possible, to the *opportunity cost* of the relevant items to the individual, firm, institution or country from whose point of view the analysis is being made.

Opportunity Cost and Shadow Prices

The opportunity cost of making a particular economic choice is given by the cost of whatever alternative production or consumption had to be foregone as a result of that choice. The allocation of labour in a village production system means that new projects introducing new work patterns need to take into account opportunity costs.

Example: The labour needed to grow fodder crops could be valued at the government's minimum wage rate of, say, US$ 5 a day. After consideration, this rate might be found artificially high, so a black market wage rate of US$ 3 per day might be applied. We may also look at the problem from the point of view of opportunity cost and ask the question, What would the farmer be doing with his time if he were not cultivating his fodder crop? If the answer is that he would be doing nothing but lying in the shade sleeping, the opportunity cost - unless he is very tired - may be nil. If the answer is that he would be drinking beer with his friends, it may be that the opportunity cost is negative - by not drinking he saves money and has fewer hangovers. Alternatively, his drinking may be a way of finding out information on marketing issues, pasture availability, local politics etc. Most often, however, the opportunity cost will be expressed in terms of another crop or of time spent trading or on craftwork or some other remunerative occupation. In order to assess the true cost of transferring the farmer's labour to fodder crop production, the cost of the *income foregone* from the alternative occupation must be estimated.

The opportunity cost of capital, i.e. of using money or investment funds, is the rate of return or interest rate that can be earned in alternative uses.

From the concept of opportunity cost, the idea of *shadow prices* can be derived. Shadow prices are used with the broad objective of bringing prices to values nearer their true opportunity cost and thus, in project analysis, they lead to the selection of projects which use up the different resources at rates reflecting the real cost to society. Shadow prices can be defined as artificial prices calculated for certain items in order to ensure that their real opportunity cost is taken into consideration when making decisions. These shadow

prices may be different from the money actually received or paid for the items at the time they are used.

Shadow prices are generally used in the following circumstances:

- Where market prices do not reflect real opportunity costs. This is often the case when prices are fixed by the government or are affected by speculators indulging in monopolistic trading.
- To accomplish particular policy objectives by encouraging the use of some items by setting artificially low prices for them and discouraging that of others by setting artificially high prices.

Thus, in project appraisal, shadow prices will present the costs and benefits of the projects at prices that: a) reflect, as far as possible, the real opportunity costs of the choices being made and the policies being proposed; and b) follow government policy by making those projects that use a higher proportion of the inputs whose use or production the government wishes to encourage, seem relatively more profitable. This is because shadow prices give such inputs an artificially low cost and such outputs an artificially high value.

Shadow prices are most commonly used in the case of two commodities:

- Labour, which can be rather difficult to value in monetary terms, as was illustrated by the example given above. Moreover, governments often want to encourage projects that use a high proportion of local labour while maintaining a relatively high minimum wage rate. A low shadow price for labour would make such projects appear relatively cheaper compared to projects substituting other inputs for local labour.
- *Foreign exchange.* Foreign exchange is a market commodity just like any other. It is accumulated by exporting and receiving aid in hard currencies and spent on imports, foreign debt repayments etc. A low price for foreign exchange means that the value of the local currency is high. This is often felt to give the country prestige and to imply a strong economy. It also makes the repayment of international loans artificially cheap. As with any other market, an artificially low price will lead to demand exceeding supply. Imports are artificially cheap, but exports are artificially expensive and hence not competitive, resulting in a shortage of foreign exchange. So governments end up restricting imports by imposing quotas, licences or banning certain commodities. One way to ensure the selection of a project that saves foreign exchange is to use a high shadow price for it.

Shadow prices can be used for any commodity if the need arises. For instance, if the objective of government policy is to raise the living standard of a particular group of

people in a country, shadow prices can be used to give a higher value to incomes gained by that group as compared to those of another group. A comprehensive system of shadow pricing based on world market prices has been devised by Little and Mirrlees.

Individuals working within a government framework attempt to use a variety of shadow prices that they have calculated themselves. Ideally, the ministry in charge of planning and appraisal should give clear guidelines as to which shadow prices are acceptable. In the absence of this, individuals should make their initial calculations at market prices, and only if they feel that there is a strong case, should they apply their own shadow prices, stating clearly what these are and how they have been derived. Because the issue of shadow pricing is a complex one, the advice of a professional economist should be sought before attempting to assign shadow prices to goods and resources.

Choice of Prices for Financial and Economic Analyses

In economic studies, a distinction is made between financial and *economic* analyses. Financial analyses examine the monetary implications of any particular activity by an individual person, enterprise or institution, looking at the actual expenses and receipts from the point of view of the individual or firm concerned. The prices used in these analyses are usually market prices.

Economic analyses study the effect of a particular activity on the whole economy. The prices used should approximate to their opportunity cost, so they may be shadow prices. Since the analysis is undertaken from the point of view of the whole economy, all prices are net of purchase taxes and subsidies.

As a study undertaken from the point of view of an individual person (firm or institution) examines the implications of a particular activity to that individual, the prices used must be those that the individual faces. Thus to a farmer who ends up buying all the supplementary feed for his cattle on the black market, the application of the government's subsidised price makes no sense. Supplying supplementary feed at subsidised prices costs the government the handling and distribution expenses plus the value of the subsidy. Whereas if a trader is involved, the feed brings him a profit if he sells it at a higher price, less his own costs of transport, handling, storage etc. These are all *financial* viewpoints.

From the nation's point of view, the cost of the supplementary feed is probably best estimated using the price paid by the livestock producer, if the feed is sold on the open market. In economic evaluations involving most agricultural and livestock products, the so called "farm-gate price", which is the price paid to the producer, should be used. The retail price paid by consumers includes the profits of middlemen, transport and handling charges etc. which do not form part of the real value of the product. Where the farm-

gate price is artificially fixed, a shadow price reflecting the black market price may be used. World market prices for particular items should only be applied if these prices are being used throughout and if the government or agency for whom the evaluation is being undertaken desires this. The distinction between economic and financial analyses will be used throughout the rest of this manual. Up to now, the word "economic" has been used to cover both aspects. Used on its own without contrasting it to the word "financial", it will continue to be the general term covering all studies of this nature.

Adjusting for Inflation -

For the purposes of project appraisal, making budgets or other economic or financial activities, it is often necessary to convert prices at current levels (i.e. for the year in which they occur) to constant values i.e. to those in a chosen base year.

Since any cost (C) is obtained by multiplying the quantity (Q) by the price (P) i.e.

$$C = P \times Q$$

it follows that, if for any year two out of the three items (C, P or Q) are known, and the price for the base year is known, costs can be converted to their value in the base year. Most commonly, it will be necessary to convert the cost of a particular item or undertaking in year n to that in the base year 0. Since the item or undertaking is the same, it follows that:

$$Q_0 = Q_n$$

so that

$$C_0 = C_n \times P_0/P_n$$

i.e. the costs in the year n are converted to costs in the base year by multiplying them by the ratio obtained when prices in the base year (P_0) are divided by those in year n (P_n). Sometimes this ratio is given in the form of a *price index* for a fixed quantity of goods.

Usually the price level in the base year 0 is assigned the number 100, so that price changes will show up as percentages of prices in year 0. Thus as the price changes, the price ratio for each year n (P_n/P_0) is calculated and multiplied by 100. Similarly, to convert costs from year n to a base year, they should be divided by the price index and multiplied by 100.

Example: Suppose that milk cost F 180 per litre in 1981 and F 250 in 1983, then the ratio 250/180 multiplied by 100 will give a price index of 139 if the base year is 1981. To create this index a constant quantity (1 litre) was used. Thus the quantity of milk bought for F 15 000 in 1981 would cost 15 000 x 139/100 or F 20 850 in 1983. Conversely, expenditure on milk of F 25 000 in 1983 would have cost 25 000/39 x 100 or F 17 986 in

1981. Often price indices are presented in a series for a fixed quantity. Thus if the 1982 price was given as F 215, the complete series would be as follows:

	Base year 1981	*Base year 1983*
1981	100	72
1982	119	84
1983	139	100

The base year in this series is given by 100. Using such a series makes it possible to convert costs from any year to those of any other, but most conveniently to the base year. Frequently an economist evaluating a project will be confronted with a series of expenditure figures extending over many years. If detailed information is not available, price indices published by government statistical services can be used in the analysis or else such indices can be put together from the existing information on prices and quantities. Until costs over a number of years have been converted to constant prices, it is meaningless to compare them, since any decreases or increases could be due to price changes.

Any project manager, planner or individual planning his finances must make it a priority to collect not only information on costs but also on prices. Ideally all quantities, prices and expenses should be recorded. In fact, since the objective is to compare expenditure or receipts at constant prices, a record of total costs and unit prices would be sufficient. Expenditure and receipts could then be converted to the base year by making price indices out of the price series. This is the most practical approach. An alternative approach is to note all quantities purchased or sold. When the moment for comparing expenditure and receipts comes, these can converted to current costs for all items since the quantities and current prices are known.

In many eases price indices actually cover a mixed sample of goods of a particular category. Examples of these include consumer price indices, share indices, construction goods indices, industrial price indices etc. In each case, the same principle applies. As before, the quantity must be fixed, but this quantity is a fixed selection of goods, usually called a "basket".

COSTS OF DISEASES AND THE BENEFITS OF THEIR CONTROL

Disease is only one of the many factors influencing the level of productivity in a production system and often cannot be considered in isolation. In order, therefore, to evaluate effectively animal disease control programmed the economics of the livestock production systems involved must be clearly understood.

Economic Aspects of Livestock Production Systems

Inputs and outputs

Describing the economic aspects of a livestock production system essentially involves the determination of the costs and quantities of the various inputs and outputs of that system. Two distinctions can usefully be made in the analysis of inputs or costs. Firstly, costs can be listed by item and the various factors of production (land, labour, capital) they apply to and, secondly, they can be classified by their degree of variability into variable and fixed costs.

Variable costs vary in the short run and directly with the amount of output produced, declining to zero if the output is zero.

Fixed costs vary only in the long run and are still incurred if output is nil. They are sometimes called overheads and cover such annual cost items as permanent labour, rent and rates, maintenance and running, and depreciation on durable goods which last for more than 1 year.

Sometimes an intermediate category of items is defined. These are integer costs, which vary with output in the medium term, such as large capital items.

A great deal of literature exists on the use of farm budgets for planning, control, analysis, and decision-making at the producer level. In farm budgets a distinction is made not only between economic and financial analyses, but also between financial and cash-flow analyses. In financial *analyses,* the actual financial position of the farmer is analysed. Depreciation, which reflects the annual reduction in value of durable goods or capital items, must be calculated. Several formulae exist, of which the simplest is:

Annual depreciation =(Replacement cost - Salvage value) / Years of productive kite

Here salvage value refers to the residual value of the machine when it is scrapped. A similar approach can be used in calculating the replacement cost of livestock. The cull value is the salvage value. The replacement cost is the price of a new animal. The formula above gives the so-called "straight-line depreciation" and must be included in fixed costs in a financial budget. A financial budget also includes the value of produce consumed at the farm.

Cash-flow budgets cover cash depreciation receipts and payments. They exclude home consumption, and depreciation but include loan receipts and repayments. If the latter were included in financial budgets as well as depreciation on equipment, for whose purchase loans had to be taken out, there would be an element of double counting. Distinguishing between the variable and the fixed costs of production is important in the analysis of disease control projects, because changes in production levels due to

disease losses or the removal of production constraints affect costs at different levels as well as output. Usually a reduction in mortality and morbidity will affect only the producer's variable costs, since these vary with the levels of output and thus usually with the number of animals. The variable costs most often affected are feed and veterinary costs.

Theoretically these are variable, but are often included with maintenance in fixed costs in farm budgets, since, unlike other variable costs, it is difficult to allocate them to individual crop or livestock enterprises.

Factors Influencing Output and Offtake

In most herd- or flock-based production systems where farmers rear their own replacement stock the choice between *present* and future consumption, between current *income* and *investment,* presents itself clearly. All producers choose to some extent between saving and investing for future consumption or consuming now. The livestock producer can make this choice at two levels:

- Livestock products, such as eggs, meat or milk, can be sold or consumed by the family or, in the case of milk, given to young animals, thus increasing their nutritional intake and probably having an effect on their survival.
- Animals can be kept or slaughtered. Females are almost always retained, though, in some systems, some are sold for meat before culling becomes necessary. Males can be retained for breeding, sold or kept in the herd as a reserve of cash, or to assist in maintaining a balanced herd.

The choice between keeping or slaughtering animals can be illustrated using the following production parameters (expressed throughout as percentages):

- GP - gross productivity per 100 animals
- AF - proportion (%) of adult females in herd
- O - annual offtake rate
- CR - calving rate
- G - annual rate of growth
- LB - live births (AF x CR x 100) per 100 animals
- CM - calf mortality
- CS - calf survivals (LB - CM)
- AM - adult mortality

Gross productivity can be expressed as births minus deaths. This gives the increase in numbers which can then be allocated between growth and offtake, i.e.:

$$GP = CS - AM = O + G$$

Without making any distinction between sexes in the surviving calves, this equation gives a rough estimate of the growth potential (from GP) of the herd at different offtake rates. It emphasises the trade-off between offtake now (O) and investment leading to growth (G) and hence offtake later i.e. the choice between present and future consumption. At this level gross productivity is fixed by the basic production parameters of calving rates and mortality. How the increase in numbers is allocated between offtake and growth is decided by the producer.

Relationship between Livestock Prices and Output

The prices which consumers or producers find acceptable for a particular item are related to the incomes or other benefits that buyers expect to gain from that item. In theoretical terms it can be stated that, in a free market the *price* of any input item which lasts for several years will approximate to the present value of the incomes expected from the use of that item over the years of its working life.

For livestock this explains, for example, why a female calf generally has a higher value than a male calf A heifer's price rises as soon as she is in calf and her fertility is proven. As a cow ages, its value declines.

In the nomadic production system in Mali the purchased inputs are nil, so the price in each year can be seen as the product of both the expected probability of an animal surviving until it is slaughtered at 7 years and the present value in each year of the slaughter prices. This gives a good approximation to the actual price and helps explain the ob xxxserved fact that prices, even per kilogram liveweight, are considerably lower for young animals.

Estimating the Cost of Disease

The quantification of the losses due to individual animal diseases follows on from the disease investigation work undertaken. Once the actual disease prevalence and/or incidence and the nature and magnitude of the losses experienced in infected herds at the regional and national levels have been defined, the economic portion of the analysis proceeds to:

- Organise, classify and present the information on disease losses.
- Quantify losses in monetary terms, choosing prices that reflect the economic or financial nature of the analysis being undertaken.
- Identify and attempt to quantify the indirect losses attributable to a disease.

Quantifying the Direct Losses Due to Disease

Direct losses are those production losses directly attributable to the presence of disease. Depending on the information available, and the needs of the study, these losses can be estimated at various levels of detail, matching the complexity of the methods used to the sophistication of the data. Two main approaches exist for quantifying disease losses:

· Given a knowledge of the production parameters of the livestock systems, and the effect of disease on them, a livestock model can be built which looks at the values of output when the disease is present and when it is absent. Such a model would, by its nature, either involve projections over a number of years or the calculation of losses for a static livestock population in equilibrium.

A dynamic evaluation, either in the context of a static herd of fixed size or of a growing livestock population, will give the most accurate estimate of disease losses. For a given disease, the values of all production parameters in the absence and presence of that disease can be entered. The difference in output with and without the disease is then calculated using the model. This type of evaluation relies on a detailed knowledge of the production system and of the effects of the disease. Small differences in the various parameters can then be estimated and valued.

— Estimates can be made of the annual level of losses associated with the disease. These can then be extrapolated over the period being studied, in line with the expected changes in livestock populations in the affected production systems and with the expected behaviour of the disease.

Methods for Estimating Annual Losses

Method 1: Losses estimated as a function of the value of the animal

Mortality: Since Method I is based on the concept that price reflects the expected future income from an animal, the cost of mortality can be calculated by applying the price by age/sex category to the number of animals in each category, and to the percentage mortality in each category, if it is known how this varies between different age/sex categories.

Morbidity: Similarly, if there are no detailed data on the effects of morbidity, its cost can be estimated as an overall lowering of output, expressed as a percentage of

— all future output from the affected animal, by using its price; or

— annual output from the average animal or the herd, in terms of milk, meat etc.

The morbidity and mortality losses can be calculated on an annual basis and adjusted for future years to reflect:

- The growth of the animal population affected.
- Any change in the animal population away from or towards more susceptible animals.
- Any change in the disease picture, following from animal health measures, changes in management practices, cycles of disease occurrence etc.

Method II: Losses itemised in terms of the effect of disease on the final output of milk, wool, meat, young animals and draught power

Mortality: This can either be calculated as above, or the present value of expected output less costs is calculated for the age/sex group or for the average animal.

Morbidity: If this is known, the losses due to disease can be calculated via the observed effects of disease, such as:

- infertility
- abortion
- delays in reaching maturity (for reproduction or sale)
- lowered production of milk, eggs, wool etc.
- lowered draught power
- lowered weight of fattened or culled animals etc.

The majority of the effects are most conveniently calculated in terms of lowered output. In some cases the loss may be more easily evaluated in terms of wasted inputs. A more sophisticated estimate would include the time value of the delay in reaching maturity calculated by discounting to obtain the present value of the costs and receipts involved. Losses in the final output can be evaluated on an annual basis and then adjusted for changes in animal numbers or in the disease picture as outlined above.

In the following example this approach was used to evaluate a sheep scab control project in Lesotho in terms of meat and wool lost. The prices quoted are in maloti (M). The total number of sheep in Lesotho is 1 200 000. The value of wool produced per sheep per year is 2.1 kg at M 1.74/kg = M 3.65. The cost of mortality per sheep is M 40 and the price received for an average animal slaughtered is M 50.

Losses due to Disease Acting as a Constraint on Production

As well as causing *direct* losses, diseases can act as constraints on production by partly determining the producer's efforts to avoid as far as possible the risks of disease in his animals. Disease control policy may bring about changes in the location of production or in the production methods used.

If a disease control policy removes a constraint, the benefits resulting from such changes are called *indirect benefits*. The losses thus avoided are called *indirect losses*. Indirect losses are particularly important in cases where the existence of a disease poses an almost absolute constraint on certain types of production or on the use of certain animals in particular areas. For example in eastern Africa, tick-transmitted diseases, particularly East Coast fever, may prohibit the introduction of improved, exotic breeds of cattle except under extremely efficient control programmed Tsetse-transmitted trypanosomiasis poses a constraint on both agricultural and livestock production tat several levels, often by limiting access to, and the full exploitation of, valuable land resources. Quantifying such effects can be complex, but it is possible. It principally involves the estimation of *changes* in the income of the producer groups involved, which would arise if the disease threat were removed and the producers were able to improve existing systems of production or adopt new ones. These *income changes* can then be related to the effects of the disease control policy.

Other losses due to animal diseases

Zoonoses. While the effects of zoonoses on human production or output in terms of lost income and the costs of treatments can be quantified, the costs of mortality and human suffering are difficult to evaluate. As well as these direct losses, indirect losses may exist where the fear of contracting a disease limits human activity.

Trade effects. Outbreaks of some diseases, particularly foot-and-mouth disease, will have a major effect on the availability of export markets to a country. An estimate of costs can be made by assuming that after an initial loss of exports, an alternative market offering lower prices can be found.

Secondary Effects

Secondary effects are effects arising upstream or downstream of the affected production process, as the dependent industries also expand. These effects are seldom evaluated, and should be reflected in the prices of the products directly affected. They can be quantified by calculating the value added at every stage of the production process affected. This "method of effects" is widely used in francophone countries and, from the theoretical point of view, is analogous to calculating and using shadow prices to estimate the opportunity cost.

Externalities occur when the production or consumption activities of one group of individuals affect another without the results being reflected in the market, in costs or m receipts. For example, pollution of a river by effluent from a firm causes damage which is not paid for by that firm. The shade given by a tree planted and owned by one individual is shared by others free of cost. One farmer's failure to vaccinate his livestock

may put at risk the livestock of the whole community. Externalities are said to be "internalised" when the costs or benefits involved are paid for in some way. For example, the firm could be required by law to install a plant for treating its effluent and rendering it harmless. The owner of the tree could charge people for sitting under it. Failure to vaccinate livestock could be subject to fines imposed by the community. In a financial analysis, if the externalities are not "internalised", they are not reflected in the costs to individuals, since no one actually pays for them. In an economic analysis some estimate of their effect should be attempted where possible. For example, the cost of pollution of a river can be measured in terms of its effect on fish mortality or on human health. Failure to vaccinate has a quantifiable effect on the direct losses due to the disease.

Intangible of disease are effects that exist but are very difficult to quantify. An example is the effect of a disease risk to people and animals on the quality of human life. People's welfare and behaviour may be modified if they no longer need fear certain diseases or losing their whole herd to rinderpest. Some aspects of this could perhaps be quantified, but generally it is acceptable to state that such effects exist and that they should be taken into consideration. This approach may also be the most practical way of dealing with some externalities.

COSTS OF CONTROLLING DISEASE

The costs of animal disease control will obviously vary not only with the disease and the type of control policy adopted, but also with the country and region in which the programme is being implemented. The reasons for this are easy to identify: different institutional frameworks, different salaries of those involved, different terrain and different production systems leading to very different transport costs. Nevertheless, it is possible to make some generalisations about the types of cost incurred and the components of these costs.

Non-medicinal Prevention

This covers preventive care within the daily routine of an animal production system. The cost is the producer's time spent observing the animals, ensuring that they have a clean environment etc. Non-medicinal prevention can include attempts to contain particular diseases by controlling livestock movements, policing borders and building fences. At a more modest level, they include the costs of protective measures undertaken at markets, the disinfection of vehicles used for transporting livestock and their products etc.

Medicinal Measures

The direct actions taken against a particular disease may include:

— Identification of a disease through diagnosis and surveys.

- Treatment of the disease, which usually entails diagnosis, treatment and follow-up. Treatment is a function of the reported incidence of the disease, which in itself often reflects the distribution of veterinary facilities and personnel, and the capacity of the veterinary service to treat a particular problem. Treatments continue to be necessary for as long as the disease remains in the population.
- Prophylaxis or vaccination. This is repeated at specified intervals once the population to be protected has been determined, either as a result of an epidemiological study and/or the producer's decision as to which animals he can afford to protect.
- Vector control, which may be repeated at determined intervals if necessary.
- Use of disease-resistant animals, which may be considered a form of disease control policy requiring experimentation, surveys and follow-up. The costs continue over the whole period during which the animals are used and are calculated in terms of the difference in productivity between resistant animals and the alternative which would have been used.

Eradication normally involves an intensification of one or more of the methods outlined above, which may be combined with a test and slaughter programme. It always involves intensive surveillance and investigative work. The initial costs of eradication are high but should be substantially reduced once the objective has been achieved. In examining and comparing different disease control policies, two aspects should be emphasised:

- The overall level of costs and their relation to the funds available.
- The *timing* of expenditures over the years. Treatments and prophylaxis typically involve costs over a number of years, while eradication demands a much higher level of expenditure but for a much shorter period. Surveillance and diagnostic work must accompany all policies. In all cases the present values of the costs.

Components of Disease Control Costs

The major components of general costs usually are:

- staff costs, including administrative costs,
- labour costs, and
- vehicle depreciation and running costs.

Added to this are costs linked to the specific nature of the project, such as:

- dip tanks and dipping chemicals,
- insecticides,

- vaccines or drug treatments,
- syringes, needles, cool boxes etc. and
- incentive payments or compensation.

In the case of more routine work, especially vaccination, it is often useful to distinguish between:

- The cost of *administering* the treatment or vaccination, sometimes called the *cost of intervention,* which includes all the costs involved in running the veterinary service and of the facilities used for the relevant treatments or vaccinations.
- The cost of *specific equipment,* such as drugs, syringes, needles etc. necessary for a particular treatment or vaccination.

Importance of Fixed and Variable Costs

As in any costing exercise, in costing disease control measures it is essential to distinguish clearly between variable and fixed costs. Variable costs include the cost of:

- drugs for treatments, vaccinations, insecticides or acaricides;
- syringes, needles and other small equipment; and
- staff travel and subsistence allowances.

Fixed costs or overheads in disease control include:

- vehicle running (this can be regarded as a semi-variable);
- permanent staff salaries;
- office running and administration;
- depreciation on vehicles, equipment and buildings; and
- office rents, rates, water and electricity.

The main objective in allocating costs into these categories is to make sure that the elements that contribute to the fixed costs are used to their maximum capacity. Projects frequently waste enormous sums of money because highly paid staff or expensive equipment are not fully utilised.

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