ISSN: 1322-624X

RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS

AN ACIAR THAI-AUSTRALIAN PROJECT

Working Paper No. 23

Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems

by

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October 1996

THE UNIVERSITY OF QUEENSLAND

ISSN 1322-624X

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[1] See page 1

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RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS is published by the Department of Economics, University of Queensland, Brisbane, 4072, Australia as a part of a research project sponsored by the Australian Centre for International Agricultural Research, viz., Project No. 9204, 'Animal Health in Thailand and Australia: Improved Methods in Diagnosis, Epidemiology, Economic and Information Management'.

The Commissioned Organization is the Queensland Department of Primary Industries. Collaborating institutions in Australia are CSIRO-ANHL, Geelong, Victoria and the University of Queensland (Department of Economics; Department of Geographical Sciences and Planning). In Thailand, the collaborating institutions are the Department of Livestock Development (National Institute of Animal Health; Disease Control Division), Chiang Mai University (Department of Agricultural Economics; Department of Animal Husbandry) and Thammasat University (Faculty of Economics). The collaborating institution in Laos is the Department of Livestock and Veterinary Services. Dr F.C. Baldock, Senior Principal Epidemiologist, Queensland Department of Primary Industries is the Project Leader in Australia and Dr P. Chamnanpood, Senior Epidemiologist, Thai Department of Livestock Development is the Project Leader in Thailand. Professor Clem Tisdell and Dr Steve Harrison, Department of Economics, University of Queensland are responsible mainly for the economic component of this project.

'The overall goal of this project is to develop and evaluate the .necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison,(s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

This is the final paper of a set of six papers by Dr S. Harrison on *Cost-Benefit Analysis with Applications to Animal Health Programmes* to be published in this series Research Papers and Reports in Animal Health Economics.

Papers in this Set

1. Cost-Benefit with applications to Animal Health Programmes: Basics of CBA, Research Paper or Report No. 18.

2. Cost-Benefit Analysis with Applications to Animal Health Programmes: Complexities of CBA, Research Paper or Report No. 19.

3. Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis, Research Paper or Report No. 20.

4. Cost-Benefit Analysis with Applications to Animal Health Programmes: Allowing for Project Risk in CBA, Research Paper or Report No. 21.

5. Cost-Benefit analysis with applications to Animal Health Programmes: Valuation of Non-Market Costs and Benefits, Research Paper or Report No. 22.

6. Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems, Research Paper or Report No. 23.

Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems

ABSTRACT

This report, which follows five earlier discussion papers on cost-benefit analysis (CBA) methods and their application to animal health programs, examines two applied areas of animal health economics in more detail. First, specific categories of costs and benefits of improved animal health are examined in more detail, with particular emphasis on foot-and-mouth disease (FMD) and other major diseases in cattle, buffaloes, pigs and poultry in Thailand. Some of the information on disease costs and AHP benefits has been derived from audience surveys carried out during the Lampang workshop. Comment will also be provided on methods which may be used for modelling and estimation of benefits of improved animal health in cost-benefit analysis. The second purpose of this discussion paper is to examine the application of CBA to animal health information systems (AHIS).

Keywords: Animal health programs, risk and uncertainty,

JEL Classification: Q16, D81

Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems

1. INTRODUCTION

This report, which follows five earlier discussion papers on cost-benefit analysis (CBA) methods and their application to animal health programs, examines two applied areas of animal health economics in more detail. First, specific categories of costs and benefits of improved animal health are examined in more detail, with particular emphasis on foot-and-mouth disease (FMD) and other major diseases in cattle, buffaloes, pigs and poultry in Thailand. Some of the information on disease costs and AHP benefits has been derived from audience surveys carried out during the Lampang workshop. Comment will also be provided on methods which may be used for modelling and estimation of benefits of improved animal health in cost-benefit analysis.

The second purpose of this discussion paper is to examine the application of CBA to animal health information systems (AHIS). While the information system component is only part of the broader strategy of implementing an animal health program, this aspect is examined in more detail because of its relevance to ACIAR project 9204. The nature of animal health information systems is examined, along with the costs involved in their establishment and maintenance, and the applications likely to be made of them. Potential benefits of animal health information systems are then considered.

Livestock diseases in Thailand lead to considerable loss of production and impediments to export of livestock products. The development of livestock industries in the rapidly expanding economy has reached a stage where animal health issues are a serious impediment to increased production and trade. Thailand has set itself the goal of eradication of Foot-and-Mouth Disease (FMD) within the next decade (Wipit, 1993). A number of other livestock diseases are of economic importance, including:

- Haemorrhagic Septicaemia (HS) and Gastrointestinal Parasitism (GIP) in cattle and buffalo
- Hog Cholera (HC)- sometimes called classical Swine Fever- and Aujeszky's Disease in pigs, and

- Newcastle Disease and Infectious Bursal Disease (IBD) in poultry.

Thailand faces special problems in that it has long land borders with Myanmar, Laos and Cambodia. The high prices for livestock associated with rapid economic progress attract stock ingress from these countries and also Vietnam. These neighbouring countries have only elementary veterinary services, hence stock entering Thailand often carry diseases.

2. ANIMAL HEALTH PROGRAM COMPONENTS

To evaluate an animal health information system, it is necessary to specify a number of disease control options. The economic implications of these can then be compared in terms of relative benefit-to-cost ratios or relative cost-effectiveness. The 'with project' and 'without project' cases need to be defined and the incremental cash-flow stream determined for each policy option. The 'without program' case may be the present disease control policy, or the policy which would have emerged if no new public initiatives were undertaken.

In general terms, national management strategies for a specific livestock disease such as FMD could involve several approaches (Ozawa, 1993):

- do nothing. Some south-east Asian countries have only rudimentary veterinary services and minimal livestock disease control strategies. For other countries - including Thailand - the 'do nothing' policy would mean a reduction in the control methods presently in place.

- maintain the current strategy. This may mean that a country has to live with particular diseases permanently, which can be a sub-optimal strategy in that there is the continuing economic losses due to the disease and the continuing control costs.

- increase the disease control effort, i.e. use more resources with a view to having lower disease costs.

- eradicate the disease. This may take a decade or more, with very high initial cost, but also very high payoff in the future. Cost-benefit analyses have typically shown eradication to be an economically desirable strategy. However, this must be technically feasible, requiring both a concerted national effort and regional co-operation. A 'worst-of-all-worlds' outcome is possible if a major eradication effort is

attempted at great expense but fails and loses community support.

In order to examine the costs of an animal health program (AHP), it is necessary to know what components will be involved in the program. Enhanced disease control strategies can utilise a number of instruments, including

- recruitment and training of veterinarians in disease diagnosis and control.

- extension programs to promote increased co-operation by livestock owners: Areas of involvement for livestock owners include identification and notification of disease outbreaks, husbandry practices to prevent infection and spread of diseases and participation in vaccination programs.

- facilities for disease diagnosis.

- a comprehensive vaccination program, e.g. 2-3 times a year for FMD in cattle with vaccination of pigs also, throughout a region or nationally. A high percentage herd immunity is required for progress in preventing disease spread, but the marginal cost of increasing coverage becomes progressively higher. Coverage achievable will depend on the extent of local veterinary services, and can be promoted by the training of village keymen to carry out vaccination, and extension and supervision effort (by veterinary officers, and even the media, national information department, police and militia).

- quarantine areas where possible and control over livestock movement into or out of areas, including the use of vaccination certificates and inspection of livestock transport vehicles, together with grazing management which reduces intermingling of herds from different villages.

- outbreak control, including ring vaccination, disinfection and "stamping out" in nominally disease-free areas.

- a comprehensive disease monitoring and information system.

In the case of a disease eradication program, there are typically a number of stages with progressively increasing intensity of action. Measures applied at any stage may differ between regions within a country, depending on regional eradication progress.

3. ANIMAL HEALTH PROGRAM COSTS

It is apparent from the above list that animal health programs can be highly expensive in terms of personnel and equipment, and can be difficult and costly to enforce. Some of the costs typical of a major national or regional animal health program, such as a disease eradication programs, are indicated in Box 1.

Box 1: Animal health program costs

COSTS TO LIVESTOCK OWNERS
DIAGNOSTIC CENTRE COSTS
INFORMATION SYSTEM COSTS
VACCINATION PRODUCTION AND DISTRIBUTION COSTS
OTHER INFRASTRUCTURE COSTS (BUILDINGS, VEHICLES, EQUIPMENT)
INSPECTION AND OTHER REGULATORY COSTS
VETERINARARY AND OTHER STAFF COSTS
ADMINISTRATIVE AND RESEARCH COSTS

An AHP can involve costs of new stock holding facilities for livestock owners, and extra labour, vaccine purchases and other costs. The labour cost may be considerable if vaccination has to be performed at a time when stock are pastured away from their normal village.

Vaccination is sometimes a major component of disease control programs, and vaccines may be purchased from abroad or produced domestically. Where a large-scale program is being carried out, the latter option will usually be more cost-effective and reliable, though this may be supplemented by vaccine imports. Vaccine distribution presents major logistic and quality control requirements, the latter involving a ‘cold chain’ to maintain vaccine viability. Distribution of vaccine may be subject to political lobbying between regions. When livestock treatment including vaccine supply is subsidised by government, the full cost of producing and distributing the vaccine and not the subsidised cost should be included in the CBA.

To introduce a major disease control program, it is necessary to have adequate diagnostic facilities for identifying cases of the disease and hence monitoring the spatial and temporal distributions of disease incidents. The facilities at the Northern Veterinary Diagnostic and Research Centre of the Thai Department of Livestock Development at Hang Chat are an

example of a modern efficient diagnosis facility. A large investment in buildings, equipment, vehicles and so on is required.

A major cost component will be the acquisition and distribution of information to support the design, implementation and continuing activities of the program. Apart from diagnostic centres, this involves obtaining animal health status reports from district veterinary officers (including information provided to them by livestock owners). It may involve carrying out active surveillance of protection levels in livestock.

Usually, controls on livestock movements will be needed, both for transport and marketing of local stock and movement of stock from neighbouring countries and between regions. Movement controls involve construction of inspection facilities at strategic transport points, adding to costs of infrastructure, vehicles and equipment.

It is probable that an AHP will involve both specialist staff recruited and trained for the program, and also some time commitment of existing staff which will take them away from normal duties. Substantial staff training and alary costs may be involved.

Compensation costs for animals which are put down in a stamping out program are not regarded as program costs in the sense that they are transfer payments from government to producer. However, the loss of these animals - in terms of market value foregone -is a program costs.

4. DISEASE COSTS

Livestock diseases give rise to a variety of costs. Box 2 provides a categorisation of the costs of livestock diseases, including parasitic diseases. The most obvious are costs of veterinary treatment, and direct production costs such as reduced mortalities, reduced or delayed weight gains and extended reproduction intervals. Diseases can prevent livestock owners from taking their stock to market at normal times, and impose extra feed costs in holding animals for a longer period to recover condition. Reduced reproduction rates can have a subtle and long-term negative impact on livestock production.

Box 2: Costs of livestock diseases

PRODUCER COSTS
LOST PRODUCTION
REDUCED REPRODUCTION RATES
LOST DRAFT AND TRANSPORT
IMPAIRED GENETIC IMPROVEMENT
INABILITY TO MODERNISE PRODUCTION
COSTS TO PRODUCERS IN OTHER INDUSTRIES
COMMUNITY COSTS
HIGHER PRICES FOR LIVESTOCK PRODUCTS
REDUCED COMMUNITY NUTRITION
LOST TRADE OPPORTUNITIES
REDUCED TRADER EARNINGS
REDUCED FOREIGN EXCHANGE EARNINGS
GOVERNMENT COSTS

Diseases tend to mask genetic differences between animals, and make genetic improvement programs more difficult (Morris, c1990). Also, development of intensively housed livestock production systems may be impossible where diseases are prevalent, because outbreaks can be devastating for large concentrations of animals. In this sense, livestock diseases can be a major impediment to development of a highly efficient low-cost high-output industry.

To the extent that diseases reduce production, they can give rise to both lower producer incomes and higher consumer prices for meat, milk and egg. If development of a large-scale efficient dairy industry is impeded, this can reduce availability of milk for children, with consequent community health impacts. Also, some livestock diseases such as tuberculosis can be transferred to humans, and other disease can cause mild illness in humans.

Perhaps the most serious cost of diseases arises for livestock industries in which a domestic surplus can be produced but access to external markets is denied. Some diseases, including FMD, affect several livestock species. Further, the presence of FMD in one cloven- hoofed animal is an impediment to trade in all cloven hoofed animals. From Thailand's viewpoint, lack of access of pigmeats to Hong Kong and Japan may have a very high opportunity cost. As well, there are reports of exports of tapioca being cancelled because the recipient country was concerned that the trucks which carried the tapioca also carried livestock which could be infected with FMD. That is, the private cost of a livestock disease may not be limited to a

single livestock industry, or even to livestock industries in aggregate.

Substantial government expenditure may be involved in existing animal health programs, including research, monitoring, regulation and subsidisation of veterinary inputs (e.g. vaccines).

5. ANIMAL HEALTH PROGRAM BENEFITS

In essence, the benefits of a new animal health program derive from disease costs avoided and additional trade opportunities. That is, under the 'with program' case, the various disease costs discussed above are reduced, relative to the 'without program' case. An extreme outcome would be where a serious disease is eradicated, hence control costs are wholly or substantially eliminated (precautionary measures and monitoring may need to be continued).

6. THE WORKSHOP SURVEYS AND RESPONSES

A series of three questionnaires were administered at the workshop on CBA and GIS at Lampang, Thailand, in January 1995. Delegates attending were mostly veterinary officers working in northern Thailand. Only a small group were present (approximately 15), and these cannot be considered a representative sample from their profession in Thailand, hence no statistical inferences can be drawn. However, most had close familiarity with animal health in their districts, and collectively they combined a great deal of experience in identification, management and control of livestock diseases.

The three questionnaires are included as Appendix A at the end of this chapter. Detailed summaries of responses are not provided because of confidentiality issues, but a general summary of findings is provided.

6.1 Important animal health problems

Parasitic diseases and FMD were considered important amongst animal health problems in beef cattle and buffalo; also of concern were haemorrhagic septicaemia (HS) and poor nutrition. In dairy cattle, infertility and reproductive problems (including brucellosis) were regarded as important health problems, with concern also over mastitis, FMD and tuberculosis.

Swine fever was judged clearly an important health problem in pigs, together with FMD and Aujesky's disease. In poultry, Newcastle disease and infectious bursal disease (FMD) were considered important, along with the CRD complex and fowl cholera.

6.2 Economic effects of diseases

Economic impacts of FMD in cattle and buffalo: Potential impacts of concern included ceased lactation or reduced milk yield, followed by cost of veterinary treatment, reduced draft power or transport, and weight loss or reduced weight gain. Less important were mortality in calves and increased turnoff age and feed consumption. Abortions and increased interval between calving were regarded as only slightly important. Similarly, reduced meat value and infertility were regarded as relatively unimportant.

Economic impacts of FMD in pigs: Weight loss or reduced weight gain were potentially important impacts, as were cost of vaccination and veterinary treatment, piglet mortalities, abortions, and inability to export pigmeats.

Economic impacts of Swine Fever in pigs: Mortalities (especially in piglets) were reported as an important impact of this disease. Other impacts included weight loss or reduced weight gain, cost of vaccination and veterinary treatment, abortions, secondary infections and marketing restrictions.

Economic impacts of Newcastle Disease in poultry: Mortalities, especially in young birds, were judged significant, followed by cost of vaccination and veterinary treatment, weight loss, reduced weight gain or morbidity and reduced egg production were also considered important effects.

6.3 Disease importance and information benefits and priorities

In terms of economic importance from a national viewpoint, FMD (in cattle, buffalo and pigs) was of concern, as was Newcastle disease in poultry and swine fever in pigs. Of lesser importance were parasitic diseases, infertility, mastitis, IBD and Aujesky's disease in pigs.

The main improvements which it was considered would result from improved information systems, in order of importance, were better long-term planning of disease management, better outbreak control, improvements in livestock quality, better allocation of new resources to animal health, and improved animal welfare.

With regard to national priorities for animal health information services, greatest priority was placed on having better co-ordination and distribution of existing information. This was followed by greater disease surveillance effort, closely followed by having more trained people in epidemiology. Only about one third ranked improved diagnosis facilities as important, perhaps because high-standard diagnostic facilities have already been developed in northern Thailand.

7. ANIMAL HEALTH PROGRAM DATA COLLECTION AND VALUATION METHODS

Box 3 lists some of the approaches to obtaining information needed for evaluation of animal health programs.

Box 3: Program benefit evaluation methods

LONGITUDINAL VILLAGE SURVEYS
LONGITUDINAL PRODUCTION STUDIES
OPPORTUNISTIC OUTBREAK STUDIES
DYNAMIC HERD SIMULATION
SUPPLY RESPONSE EVALUATION
CONSUMER DEMAND AND ELASTICITY STUDIES
INTERNATIONAL MARKET ASSESSMENT
NON-MARKET IMPACT ASSESSMENT

In that livestock owners tend not to notify officials about cases of important livestock diseases, and may in fact be unable to identify diseases with any confidence, *passive surveillance* methods can be quite ineffective. This has been the rationale for *active surveillance* measures involving repeated surveys and taking and testing blood samples, introduced in the current ACIAR project 9204. The surveys and blood sampling have been repeated at regular intervals, hence the term *longitudinal surveys*. These surveys require complex multi-stage sampling designs, and depend on availability of up-to-date diagnostic facilities.

Measurement of economic losses from reduced weight gains can be difficult. *Compensatory weight gains* may offset some or all of the weight loss or reduced gain from disease. More research is needed to establish relationships to estimate net losses. At the same time,

allowance may be needed for increased feed requirements associated with the compensatory gains, and opportunity costs associated with delayed turnoff.

To estimate the production costs of diseases it is necessary to monitor livestock performance over a number of years (*longitudinal production studies*). This approach can answer difficult questions about compensatory weight gains and losses in reproduction. In such studies, it would be useful to carry out intensive observations for some outbreak cases. Regular weight recording of a sample of animals over time would provide data for more precise modelling of disease impacts. Weights of selected animals could be obtained by passing them over scales, or by inferring weights from girth measurements.

Perhaps the best way to estimate the production benefits of improved animal health is to develop a computer model which can be used to simulate production on individual properties or in a regional herd, over a number of years. This approach allows economic performance over time to be estimated, both with and without a new animal health program. In the simulation model, weight gain, feed conversion ratios, reproduction rate, and mortality and morbidity rates can be treated as parameters the values of which are functions of the design options chosen for the animal health program.

The estimation of changes in consumer surplus requires a good understanding of demand conditions in markets for livestock products, i.e. demand functions and price elasticities. Estimation of these price elasticities could utilise econometric analysis of time- series market data, or simply rely on estimates from previous studies in other rapidly developing countries. For estimating trade benefits of improved animal health, it is necessary to obtain market data in importing areas or countries, and to forecast future demand using say quantity *balance sheet* methods.

To the extent that animal welfare issues, environmental impacts, use of livestock in recreation and so on are affected, non-market valuation techniques can be applied to estimate these benefits and costs, as outlined in the previous discussion paper in this series.

Various other issues may be raised when considering cost and benefit estimation for AHPs. Strategies need to be considered at both a regional and national level. Socio-economic factors will influence co-operation and adoption of control measures by villagers, e.g. in areas where there is substantial off-farm employment the inputs to livestock husbandry may decline or there may be greater risk of disease introduction. Costs and benefits for individual producers

and consumers need to be adjusted for transfer payments, and aggregated to regional and national levels, and combined with trader and government costs and benefits. A risk assessment of alternative programs would be highly desirable. For example, in the efforts of Thailand to eradicate FMD there is risk of re-entry of the virus from neighbouring countries, and risk of outbreaks from strains of FMD virus for which no vaccination currently is carried out, including potential new strains.

8. CBA OF ANIMAL HEALTH INFORMATION SYSTEMS

As indicated above, development of information systems for monitoring of animal health and of progress in disease control programs is a major focus of ACIAR project 9204. This project is designed to further develop the existing livestock information system in Thailand, using state-of-the-art diagnosis techniques, active surveillance and modern geographical information system (GIS) information technology. ACIAR project 9204 is addressing the question of whether development of animal health information system is worthwhile in terms of the payoff to expenditure on development and maintenance of the system, and how economically justified and cost-effective epidemiology management policies can be designed.

The value of information systems for decision support is being increasingly recognised, and animal health programs are no exception. To design an effective animal health program at a national level, information is needed on the various diseases present, their economic significance, their spatial distribution and frequency of outbreaks,-risk factors, vaccination coverage and immunity status, and so on. Control or eradication of diseases can involve considerable information demands.

A well-equipped disease diagnosis facility and highly trained epidemiologists to carry out tests on blood samples and sick and dead animals is obviously a fundamental component of an AIDS. But as well, the compilation, recording and analysis of epidemiology data, and dissemination to decision makers of timely information in a readily used format is also vital. GIS technology provides a highly effective approach to this information management component.

Substantial expenditures may need to be incurred in the short term, to establish and utilise the disease control information system, with main benefits not enjoyed for a number of years.

Economic analysis can measure the likely benefits of an information system relative to the cost, and the way in which such a system can be introduced and used in the most cost-effective manner. From a national policy viewpoint, it is necessary to identify social (i.e. public) as distinct from private costs and benefits, and these may differ considerable for animal health programs. This may be approached by first estimating aggregate private benefits, and then making additions and adjustments to cost and benefit items.

In the following sections, the concept of value of information is examined, and components and costs of AHIS establishment and maintenance are discussed. The types of benefits which can then arise from availability of improved animal health information are then reviewed.

9. ECONOMIC GAINS FROM IMPROVED INFORMATION

Information may be considered as one of the various resources of a firm or government agency. Information is used in production, is scarce and has value. The value of information derives from the improvements in decisions and hence greater revenues which it makes possible.

The extent to which data collection and information system development is undertaken can be viewed as an economic decision. The benefits from an information system in terms of improved decision making and consequently higher earnings, lower costs and so on, should outweigh the costs of developing and maintaining the system. In terms of system design, this needs to be viewed in a marginal context: extra expenditure is only justified as long it is more than compensated by extra payoff.

Information systems are sometimes examined in terms of Bayesian decision theory (e.g. see Harrison and Tamaschke, 1984, Ch. 15). A decision maker possesses a particular amount of *prior* information, which defines probability distributions of uncertain program variables. *Additional* information may be obtained from surveys or other sources. Once this additional information is obtained, it may be combined with the prior information. Specifically, estimated *likelihoods* or conditional probabilities may be combined with *prior probabilities* to obtain *posterior probabilities*, using Bayesian techniques. Ideally, perfect information would be obtained, in which case the *expected value of perfect information* could be determined with respect to returns from improved management strategies. Any information which can be obtained will of course be imperfect.

Additional information is usually obtained by objective means, and although this will not always involve specific-purpose surveys for generality the term *sample information* may be used. Based on an analysis of all possible sample outcomes, and their probability given the observed sample results, it is possible to estimate the *expected value of sample information* or EVSI. Subtracting the *cost of sampling* COS yields the *expected net gain from sampling* ENGS, i.e.

$$ENGS = EVSI - COS$$

It is worthwhile obtaining additional information - such as by introducing an *active surveillance* program - so long as the ENGS is positive. Further, the amount of sampling of sample size should be chosen so as to maximise the ENGS.

10. THE NATURE OF AN ANIMAL HEALTH INFORMATION SYSTEM

10.1 Defining the system and its boundaries

One of the most difficult tasks in CBA is to define the program or project to be evaluated, including the relevant system boundaries, variables and interrelationships. The system to be considered must obviously be wider than the information system alone, since information is only of value if it leads to improved decision making. The information will be of value only inasmuch as it reinforces on-farm, regional or national disease eradication or minimisation programs. It is necessary to examine how the information generated will be used, i.e. to consider the animal health program that is likely to result. Economic evaluation of a disease information system needs to examine costs and benefits from the producer through to the national level

The AHIS is in effect only part of an overall epidemiology management system, and cannot sensibly be evaluated in isolation from other components. The evaluations needs to be within the context of the livestock production and marketing systems, from the management practices and socio-economic circumstances of individual producers through to domestic and export marketing, and of national livestock development priorities. It is only by examining disease management within the context of this wider livestock management system that meaningful policy advice can be generated.

At the village level, disease control programs require a high level of co-operation of livestock

owners. Without this, the threshold percentage of protected herds needed to bring about effective control will not be possible. The extent to which livestock owners are willing and able to participate in control programs such as comprehensive vaccination depends on a number of factors. Some of these such as attitudes and husbandry practices are amenable to extension effort. Others such as extent of off-farm Work and time available for tending livestock are not. The effectiveness of control programs needs to be viewed within the context of village socio-economic systems.

10.2 Components of the information system

An animal health information system will include data collection, storage and analysis, as well as regular reporting to decision makers. Some of the components which could make up such a system are indicated in Box 4.

Box 4: Components of the AHIS

FIELD OBSERVATION AND MONITORING
- REPORTING OF CASES BY LIVESTOCK OWNERS
- ACTIVE SURVEILLANCE

DISEASE DIAGNOSIS
- FIELD INSPECTIONS BY VETERINARY STAFF
- LABORATORY DIAGNOSIS

DATA RECORDING, UPDATING, ANALYSIS AND REPORTING
- DATA TRANSFER TO CENTRAL LOCATIONS
- ELECTRONIC STORAGE AND ANALYSIS
- DISSEMINATION OF REPORTS TO DECISION MAKERS

Of particular importance is a capability to identify diseases, which involves both field and laboratory diagnosis. The information system essentially needs to be national in coverage, but with ability to focus on particular regions. Potentially, a huge amount of information will to be stored. Timelines of reporting is essential for rapid action in the event of a disease outbreak. Geographical information systems technology offer the capability to handle huge amounts of information and produce automatically a range of reports on spatial characteristics of disease incidence, correlation with risk factors and (with inclusion of modelling) forecasts of disease spread.

10.3 Sampling considerations in active surveillance

Reliable information on disease incidence and protection levels is essential for an AHIS. Where serious under-reporting of cases by livestock owners takes place, a proactive data collection procedure (active surveillance) is necessary to obtain this information. This can take the form of regular sample surveys in which blood specimens are collected from animals for laboratory estimation of blood titre levels with respect to target diseases. For active surveillance of say FMD in cattle and buffalo, it is necessary to collect blood specimens at regular intervals from a sample of animals selected at random from the target area, then to make inferences to the reference population on the basis of the sample data. Specifically, point and confidence interval estimates can be made of the proportion of animals protected (whether by vaccination or exposure to the disease), and of changes in the proportion protected between periods over time.

If carried out over a large region, this sampling procedure to obtain further information can be a highly expensive and labour intensive process. In determining the expected net gain from sampling, it is necessary to place a value on the information obtained and to determine sampling costs. The most efficient sampling design (with lowest cost relative to the value of information yielded) is obtained by using *multistage sampling*. The first stage of sampling consists of selecting villages at random from a sampling frame consisting of a list of all villages in the target region. (A modification which would increase efficiency would be to select a common proportion of villages from each sub-region, e.g. each province or district.) In the second stage of sampling, a number of animals is chosen at random from each selected village.

A recommended approach to sampling from a target region is *two-stage sampling with probability proportional to size*. This would use a design such as the (30,7) configuration of primary and elementary sampling units which is widely adopted by the World Health Organisation. Under this design, 30 villages would be selected by a random procedure but with probability of selection related to the number of subjects (cattle and buffalo) they contain. In the second stage, a fixed number of seven subjects (animals) is chosen at random from each selected village.

For PPS sampling to be applied, it is necessary to know approximate numbers of subjects in each primary sampling unit, e.g. approximate numbers of cattle and buffalo in each village. The higher probability weighting of large villages is offset by the smaller proportion of

subjects selected from large villages (constant quota of seven), such that the sampling procedure is *self-weighting*, i.e. each subject in the target region has an equal chance of being selected in the sample. Under this sampling design, primary sampling units (villages) are usually selected *with replacement*, so that any village may be selected more than once, while elementary sampling units are selected *without replacement*, i.e. the same beast cannot be selected twice.

The cost of sampling (COS) under a two-stage PPS design may be estimated as:

$$COS = c_1 + Cz\ m + c_3\ mn$$

where c_1 represents the overhead costs of setting up and managing the data collection procedure (survey and laboratory diagnosis)

c_2 is the cost per primary sampling unit
m is the number of primary sampling units in the target population
c_3 is the extra cost of sampling for each elementary sampling unit
n is the number of elementary sampling units in each primary sampling unit (e.g. number of beasts per selected village)
mn is the overall sample size.

If the parameters c_1, c_2 and c_3 are known, and estimates of the population variance are available, it is possible to determine a sampling design which will minimise cost for a given level of precision in terms of standard error of population estimates.

Where no sampling frame of villages is available, resort may have to be made to a locational sampling approach such as *grid sampling*, in which coordinates are chosen randomly on a map then one or more villages near selected coordinates is chosen for the sample. If the coordinates are chosen at random without restriction, a difficulty which would need to be overcome is to avoid selecting too many remote villages and too few in areas where villages are clustered. This could be achieved by classifying regions according to degree of remoteness, and specifying numbers of villages to be selected from each region prior to sampling.

The design of a multistage sampling plan, and subsequent analysis of survey data, is by no means a simple task. A relatively readable explanation of the complex statistical basis and

derivation of formulae for obtaining sample estimators is provided by Yamane (1966). These sampling issues have been faced in setting up longitudinal surveys for active surveillance of FMD in cattle and buffalo in three northern provinces in Thailand.

10.4 Information system technology applied to livestock diseases

The nature of animal health information systems and the their application in ACIAR project 9204 has been examined by Sharma (1993, and this workshop). In Thailand, active surveillance and GIS information technology is replacing existing passive surveillance methods. In order to evaluate the economics of an enhanced disease information system, it is necessary to identify how such a system would be structured, maintained and used. A brief description only will be provided here.

A GIS is an organised collection of computer hardware, software, and personnel designed to efficiently capture, store, update, manipulate and analyse geographically referenced information (information with can be mapped). System capabilities include

- data capture, input and conversions
- data manipulation, query, modelling and analysis
- data display and output.

Geographic data are available from a wide variety of sources including printed maps, field observations, surveys, printed reports, sensors (e.g. satellites), geo positioning system (GPS), data loggers of various kinds, etc. To be usable in a computer all data have to be in a digital form. Where maps have not already been digitised, the first task in setting up a GIS is digitisation of the map base. Here maps indicating villages, roads, rivers and so on are converted through manual entry of points, lines and polygons using a digitiser (an electronic tablet on which a map is placed and relevant contents 'traced'). Conversion of paper records and printed maps is perhaps the most expensive and time consuming part of setting up a GIS. For some data, potential exists for automatic entry at the time of data capture, e.g. using a data logger or geographic positioning system (GPS).

With regard to data manipulation, query, modelling and analysis, three types of operations may be identified, viz.

- preprocessing: including editing of errors and performing various geometric

manipulations which may be necessary before any analysis can be undertaken. Operations include joining maps (edgematching), scale changes, format conversions, and data transformations.

- automated mapping: conventional map drawing, but using a computer.
- analysis and modelling functions: advanced mapping functions include retrieval; classification and measurement functions; map overlay and buffering operations; neighbourhood operations and connectivity analyses.

Results of the GIS analysis are reported to the users as automated mapping and other geographic analyses and modelling (e.g. tables, charts). These outputs are in effect the information provided to decision makers.

With regard to GIS hardware, physical devices to capture, store, process and output data can be organised to operate as single user or multi-user systems. Input devices vary by type of operation required. Text entry is via keyboard while digitisers and scanners are needed for the entry of graphic data. A relatively fast microcomputer with a large amount of memory is desirable, e.g. a Pentium 133 with a one Gb hard disk and 32Mb of RAM. Output devices include VDUs and hardcopy devices such as line printers, plotters and film recorders.

10.5 Costs of an AHIS

Development of an AHIS requires considerable planning and implementation effort, as illustrated in Table 1.

Table 1: GIS operational steps

Planning steps:
Requirements analysis
User needs specification
Data acquisition
Conceptual design of the system
Information system feasibility study
Produce discussion paper of design
Refine design in the light of comments
Implementation steps:
Draw up implementation plan
Carry out database design
Enter available statistical data into database
Data conversion (digitisation) of map base and other information
Purchase and installation of hardware and software
User training
System testing via a pilot study
System audit, review and upgrades
Maintenance steps:
Routine data collection
Specific data collection programs
Production and dissemination of reports
Software and hardware upgrades
Power (electricity) and expendables (paper, ribbons, disks, etc)

Cost categories in the development of information systems are reasonably well understood and identifiable (e.g. see Lyons et. al., 1993). The steps outlined above in setting up an AHIS obviously involve various costs. Major categories include costs of staff time, purchase of hardware and software items, and expendables. Considerable infrastructure may be required to house the system, and to provide communications between the various centres of operation. While computer hardware and software is the most obvious cost, it may comprise

only of the order of 10%-20% of overall costs. As well, there may be substantial recurrent costs in *maintenance* of the system over time. These would include updating the information in the database, and acquiring hardware and software upgrades.

11. ECONOMIC BENEFITS OF AN AHIS

In general terms, the benefits of a computerised and efficient animal health . information system may be considered from several perspectives:

Reduced costs of providing decision-support information. Intuitively, a powerful computer-based information system could drastically reduce labour costs in analysing data and developing summaries, charts and so on to aid managers. In practice, electronic information systems such as GIS rarely reduce costs of providing information; rather, they involve greater cost to produce higher quality information. However, economic evaluation of the improved information is usually quite difficult, involving estimates with a high degree of uncertainty. For this reason, many of the cost-benefit studies in published reports compare the costs of the new information- system using electronic technology with what the new information system would have cost if *paper-based* technology were adopted. Placing dollar (or baht) values on benefits of improved information presents a challenge for economists. Such an analysis is reasonably clearcut and workable, but avoids the difficult valuation issues of added benefits of the information system.

Greater timeliness and convenience in providing information to support an animal health program. An electronic information system may be a critical element for success of an animal health program, because paper-based methods would be unable to provide the type of information required within reasonable time requirements, staff availability and so on. In terms of the "without system" case, the program simply would not be introduced without the information system.

Value-adding benefits from improved information provision. Sometimes an electronic information system will allow various useful tasks to be performed which would not be undertaken otherwise, even though an animal health program has been implemented.

More specifically, the outputs of the information system being developed will have a number of applications in disease control and monitoring:

- tactical response to disease outbreaks. Better information could allow a more informed and rapid response to any outbreak.

- targeting of diagnosis. A knowledge of risk classes by type disease, district and livestock type could be used to guide diagnosis and surveillance strategies.

- assigning priorities between diseases for expenditure of the disease control budget, based on frequency and extent of outbreaks and costs of control measures introduced.

- better deployment of existing resources for disease management, hence more effective use or reduced resource requirement.

- infrastructure and resource planning. Information on disease risk could be used to guide design and placement of new infrastructure and deployment of new resources for control programs and emergency preparedness.

- strategic planning. The information could be used to guide development of long-term strategies for disease eradication or minimisation. Expenditure priorities in terms of disease type and district could be established on a rational basis.

- demonstration to trading partners and international monitoring bodies of the disease-free status of a country or particular regions in a country.

The implementation of disease information could have a number of economic benefits, in terms of improved animal health which the information system supports. While these would not be easy to quantify, in general terms they could relate to:

- more rapid response to a disease outbreak, hence reduced spread and lower producer losses.

- trade benefits from assurance of product quality.

- cost savings in deployment of existing and additional resources for disease outbreak control.

- lower ill-health of veterinary workers, livestock owners, meatworkers, etc, with consequent reduced costs of health care and lost labour hours.

- improved community health hence lower health costs and greater productivity.

- existence values not readily quantified such as improved animal welfare or greater community peace of mind.
- cost saving in replacing existing paper-based and labour-intensive information systems.
- more rapid regional disease eradication hence increased trade opportunities resulting in higher product prices.
- more rapid recognition as a disease free area and earlier access to foreign markets.
- lower costs in meeting essential information requirements, e.g. for statutory administrative reporting, international obligations, community health.

When carrying out CBA of an animal health information system, it is important to apportion benefits between the animal health program and the information system per se. It would obviously be incorrect to attribute the entire benefits of the animal health program to the information system, even when this system is broadly defined as in Box 4.

12. RISK ANALYSIS WITH RESPECT TO SUCCESS OF THE INFORMATION SYSTEM

There are a number of sources of risk with respect to economic performance of national programs involving development of animal health information systems. There is anecdotal evidence that many information systems "fail". While failure due to lack of performance by hardware is becoming rare, failure can often be attributed to lack of usage of the system by intended or potential clients. Lack of usage can be related, amongst other things, to difficulty of use, availability of better information from other sources and failure to deliver user-relevant information. The information system needs to be in line with the business plan of the organisation, and regarded as essential part of the organisation's core activities. It also needs to meet the broader organisational strategy and measure up in economic terms.

There is substantial risk concerning the extent and timing of success of animal health programs, particularly those designed to eradicate highly infectious diseases such as FMD. The time which eradication this will take is highly uncertain, depending for example on success in preventing reintroduction from neighbouring countries and vaccination coverage

rate achieved.

13. CONCLUDING COMMENTS

A variety of cost and benefit categories may be identified for animal health programs. Benefits include but are not limited to producer impacts including increased livestock weight gains and reproduction rates, reduced veterinary costs, and draft and transport benefits. Consumer gains relate to reduced food prices, improved nutrition and reduced risk of disease. New trade access can be expected to increase incomes of livestock producers and traders, but may force consumer to pay higher prices for livestock products. Animal health programs can involve huge explicit costs, including provision of infrastructure, vaccine production and subsidised distribution, information (including diagnosis) costs, and extension and enforcement costs. There may also be substantial implicit costs, such as increased landholder and agency labour inputs. Producers may not greet with enthusiasm programs such as universal stock vaccination, compulsory notification with regard to sick animals and controls on livestock movements.

Important insights into animal health problems and benefits of control programs were gained at the Lampang CBNGIS workshop. A series of questionnaires on attitudes to economic aspects of livestock diseases was administered at this workshop.

Comments have also been provided on the economic analysis of animal health information systems such as that being established in northern Thailand for FMD. While considerable theoretical research has been carried out into the value of information, in practice it can be difficult to predict the beneficial uses to which improved animal health information will be put.

High quality information is crucial to implementation and monitoring of a major animal health program such as disease eradication. Geographic information systems provided an integrated approach to dealing with large volumes of spatial data which is regularly updated over time and from which regular reports to management are generated. The Arclnfo GIS being trialled for FMD in northern Thailand is a good example of such an information system.

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APPENDIX A: WORKSHOP QUESTIONNAIRES[1]

QUESTIONNAIRE 1: IDENTIFICATION OF ANIMAL HEALTH PROBLEMS

1 What do you consider are the important animal health problems for beef cattle and buffalo in Thailand? (Please name any specific disease, pest, nutrition, injury, etc, problems you consider to be of economic significance.)

2 What do you consider are the important animal health problems for dairy cattle in Thailand? (Please name any specific disease, pest, nutrition, injury, etc problems you consider to be of economic significance.)

3 What do you consider are the important animal health problems for pigs in Thailand? (Please name any specific disease, pest, nutrition, injury, etc problems you consider to be of economic significance.)

4 What do you consider are the important animal health problems for poultry in Thailand? (Please name any specific disease, pest, nutrition, injury, etc problems you consider to be of economic significance.)

5 For each of the above four questions, number the three most important animal health problems in order of importance (e.g. for beef cattle and buffalo, place the number 1 alongside the most important, 2 for next most important and 3 for third most important).

[1] In these questionnaires, spaces for responses have been condensed to reduce size.

QUESTIONNAIRE 2: ECONOMIC EFFECTS OF SOME IMPORTANT LIVESTOCK DISEASES

1 Which of the following effects are caused by foot-and-mouth disease in cattle and buffalo? Please tick the appropriate box.

Effect of disease	Importance ranking				
	Not impt.	Slightly impt.	Moder-ately impt.	Quite impt.	Very impt.
Weight loss or reduced weight gain					
Reduced meat value					
Increased turnoff age & feed consumption					
Abortions					
Infertility					
Increased interval between calvings					
Ceased lactation or reduced milk yield					
Mortalities in calves					
Mortality in young and mature stock					
Cost of veterinary treatment					
Reduced draft power or transport					
Other (please name)					

2 What do you regard as the effects of Foot-and-Mouth Disease in pigs which cause economic loss? Please list and number most important three.

3 What do you regard as the effects of Swine Fever in pigs causing economic loss? Please list and number most important three.

4 What do you regard as the effects of Newcastle Disease in poultry causing economic loss? Please list and number most important three.

QUESTIONNAIRE 3: DISEASE IMPORTANCE AND INFORMATION BENEFITS AND PRIORITIES

1 Disease importance

How would you rank the following livestock diseases in order of economic importance from a national viewpoint (to producers, consumers, traders and government)? Please rank the four you consider most important by placing the numbers 1 to 4 alongside them.

Aujesky's disease
Foot-and-mouth disease
Infectious bursal disease in poultry Infertility problems in dairy cattle
Mastitis in dairy cattle
Newcastle disease in poultry
Parasitic diseases in cattle and buffalo
Swine fever

2 Impacts of improved information system

If an improved animal health information system were available, what do you think would be the main improvements which would result? Please rank the four items in the following list you consider most important by placing the numbers 1 to 4 alongside them.

Better allocation of existing resources
Better allocation of new resources
Better long-term planning of disease management
Better control over disease outbreaks
Improvement in livestock quality
Modernisation of livestock industries
More regional development Improved animal welfare
Other (please name)

3 Expenditure priorities

What do you think national priorities should be with respect to the following measures for providing improved animal health information services? Please rank the three you consider most important by placing the numbers 1 to 3 alongside them.

Greater disease surveillance effort
Improved disease diagnosis facilities
Better co-ordination and distribution of information
More trained people in epidemiology
Other (please name)

4 Information for veterinarians

(a) Do you have the necessary information to do your job (yes/no)?

(b) Would more information help you to do your job better (yes/no)?

(c) If yes to (b), what kind of information would assist you in your job?

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