Epidémiol. santé anim., 1997, 31-32

LINKING GIS WITH ECONOMIC MODELS FOR MANAGING LIVESTOCK HEALTH : POSSIBILITIES AND CONSTRAINTS

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En vue de développer un système géographique d'informations sanitaires (GIS) et d'évaluation économique des plans de lutte contre la fièvre aphteuse, une expérience menée en Thaïlande est rapportée. Plusieurs possibilités pour l'intégration économique en modélisation et GIS d'aide à la décision dans les programmes de santé animale sont notées.
Elles vont de l'estimation économique appliquée à des études sur le Système d'Informations Géographiques, en passant par la modélisation spatiale des variables économiques, jusqu'à l'intégration comme des modèles de simulations dynamiques complexes.
Les difficultés à combiner les deux approches sont examinées.

INTRODUCTION

In the joint Thai-Australian animal health project[2], a GIS has been used to map livestock characteristics and disease control information in three north-western Thai provinces. The project also has an economic component[3], and this has provided the opportunity for integration of the two research approaches. GIS facilitates a spatial approach to economic analysis. GIS applications to animal health have been reviewed by Sharma (1994). This paper discusses integration of economic analysis with GIS to generate information to support public animal health programs, and examines constraints which prevent closer integration, based on experience in Thailand.

Animal health management presents a number of tasks for livestock authorities in developing countries, in terms of planning, monitoring and control of outbreaks, all of which have substantial information requirements. The objective is often control and eradication (C&E) of a major disease, such as the case of FMD in Thailand, which requires a close understanding of the factors associated with outbreaks (risk factors), and tailoring measures on a regional basis. Risk factors include high livestock density, spatial gaps in protection, livestock imports and smuggling, domestic stock movements including selling, intermingling of herds, feeding offal to pigs, predisposition by poor nutrition, and weather conditions. Monitoring involves information collection by means of passive or active surveillance, i.e. routine reporting or special purpose sampling.

Decisions about animal health measures are made by producers and government. Decision makers have substantial information needs concerning present animal health status and effectiveness of their control programs. Both GIS and economic models are in essence methods of generating quantitative and qualitative information for decision-support. Managers typically have prior information which, combined with intuition and judgement, leads to tentative decisions or policies. Information provided by electronic information systems and technical specialists including economists will augment existing knowledge, serving to confirm or challenge tentative decisions.

OBJECTIVES AND OUTPUTS OF GIS AND ECONOMIC MODELS

As there is a geography associated with livestock production and health it is not surprising that GIS can be used for a wide range of applications. A GIS is a computer-based system for the management of geographically referenced data. It is particularly useful for identifying and monitoring disease risk factors, and for identifying spatial relationships between variables (such as between disease incidence and various risk factors). GIS are well suited for the consolidation of data to gain overall regional and national pictures (literally, by maps), and for generation of reports for various purposes. A GIS may also be used to aid planning animal health programs, monitoring animal health and program performance, or responding to an outbreak emergency. Considerable effort is being made to improve information systems of animal health in south-east Asia (ASEAN/OIE 1996), and GIS are likely to play an increasing role in this initiative.

Economists take a social cost-benefit perspective of animal health programs. Their interest is with costs incurred by disease, costs of control, and benefits gained by control, from the producer through to the regional, national and export levels, as well as for consumers. Economists are also interested in demand and supply functions and "elasticities", such as how well a livestock industry is able to expand in terms of access to land and feed resources. Economic analysis may be used to determine if a C&E program is desirable (on social cost-benefit grounds) or, if a program has been accepted, to aid cost-effective implement.

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2 Research support has been provided under ACIAR Project 9204: Animal Health in Thailand and Australia: Improved Methods in Diagnosis, Epidemiology, Economics and Information Management.

3 Reports of this work are included the series *Research Papers and Reports in Animal Health Economics*, Department of Economics, The University of Queensland, Brisbane.

INTEGRATION POSSIBILITIES

Various opportunities exist for integration of GIS and economic analysis:

1. Economic analysis may be applied to aid design of the GIS, e.g. with regard to the role and spatial coverage.
2. Various GIS output such as maps, charts and tables of densities of animal populations, production parameters and disease control measures may be used as inputs for economic analysis.
3. A GIS may be used to produce maps of variables of particular economic interest, such as livestock numbers or values, price differentials, disease costs, control expenditures and movement control points. Any number of variables of economic significance may be mapped - the resulting spatial patterns may themselves spur a line of economic analysis. As FMD control strategies needs to be designed on a spatial basis, with different packages of control measures in different regions, there is a need to determine where reinfection is coming from (e.g. illegal stock imports, remote villages with low vaccination, areas where village herds intermingle in the cropping season). Price gradients will influence movements into the country (legal and smuggling) and movements within the country (for fattening or sale). The mapping of livestock values, disease costs and so on could help in designing control strategies. Economic data on the value (and prices) of animals located in an area and the cost of carrying out control measures would be useful for deciding on controls. The spatial pattern of vaccination coverage could be examined in relation to vaccination cost, and opportunities for cost-effective increase in coverage identified, e.g. for village swine. In principle, the spatial distribution of total value of animals could be represented in a GIS. Areas containing a higher valued collection of animals should be given greater priority for public response to an outbreak of a contagious disease if more than one area is involved, other things being equal. Where FMD eradication is least costly, the policy of "going for broke" to obtain regional freedom could be advocated. GIS models which incorporate data on livestock prices and show stock movements could be useful in indicating areas of different degrees of risk of spread of livestock diseases. Risk indicators might be prepared for various regions. Cost-effectiveness of vaccination programs could be monitored on a district or regional basis.
4. Overlaying may be used to examine the relationship between risk factors and livestock values.
5. The possibility exists for linking GIS models of livestock data to regional input-output models and deriving economic multipliers, e.g. the economic impact of an outbreak of a significant livestock disease in a region could be estimated.
6. Dynamic and stochastic epidemiology/economic simulation models could be interfaced with animal health GIS. Such models could be used to simulate alternative disease control options, and assist in determining optimal program plans or outbreak response policies.
7. In a cost-benefit study, livestock species and herd size distributions contained in a GIS database could be used to aggregate disease costs and control costs and benefits through to regional and national totals.

OBSTACLES, CONSTRAINTS AND UNREALISTIC EXPECTATIONS

In practice, the linking of GIS and economic models faces a number of constraints.

Difficulties in interdisciplinary research

Researchers face a learning time in becoming familiar with the paradigms, methods, capabilities and opportunities of professionals in other disciplines. These issues are frequently reflected in problems associated with data. In the Thai-Australian project there were essentially three sets of data requirements: to set up the foundations of the GIS (essentially defining the spatial resolution of the database); to meet animal health objectives (blood samples for lab testing) ; and to conduct various economic analyses. Because of lack of coordination and integration among the three objectives the GIS database that was created failed to satisfy all users.

Unrealistic expectations

The ACIAR project also highlights unrealistic expectations about development of an "all singing all dancing" animal health information system and what it would or could deliver. There is enough collective wisdom about national information systems (animal health or otherwise, but especially from population census type systems) that national level systems can provide only key indicators to profile the population by reasonably fine areal units. Any detailed studies are expected to use the profile to develop their own (generally sampling-based) data collection.

Issues relating to scale of representation

The three province pilot GIS that was set up in northern Thailand provides at the subdistrict, if not at the village level, considerable livestock and disease information, as well as various administrative information relating to disease control strategy are available (Thailand can be divided into approximately 8000 subdistricts and 60,000 villages). The system can include biophysical modelling to predict future livestock numbers, production, trade flows and disease protection and health status. Such a system can provide a wealth of background information for economic analysis. The pilot system can be easily extended to cover the whole country – cost is not a major consideration. However, it is probably still futuristic to imagine a national GIS could be developed that does everything livestock authorities would want; such a national system may be neither necessary nor feasible to develop (it is also likely to be exorbitantly expensive). There is a tendency nowadays to set data definition and management standards centrally, but have local data repositories which can be accessed from all points in a network, allowing in particular creation of specialised datasets (for economic analysis, for example) where necessary.

Variables not mapable
Another illustration of the problem for data integration relates to the interpretation of sample results. An example is the seroprevalence of FMD as revealed by active surveillance involving taking blood specimens and determining FMD titres from 30 villages spread over three provinces (a 1% sample of villages) which allows economists to make acceptable statistical inferences; however, the number of observations is too small for the GIS software to interpolate between observation and derive density contours for the study area.

Different data requirements
Much of the information needed for economic analysis is not normally represented in an animal health information system. The cost of disease to owners of cattle and buffaloes involves loss of production, reproduction, draft and transport. Impacts on consumers arise from changed prices of meat and other livestock products. Also important is the impact of disease eradication on allowing access to foreign meat markets. When examining the response of livestock owners to disease notification regulations or vaccination programs, economists need to consider livestock owners' resources, attitudes and practices. They are concerned with human behaviour, and responses to incentive systems.

Data unavailability
Even where obvious potential exists for integration of GIS and economic analysis, the data needed to generate relevant information for decision-support often are not available. Access to data can be a major constraint for economic analysis of livestock systems in distant country, with a different language, with sensitivities about disclosure of livestock disease levels. For the ACIAR project, a further problem was lack of a project economist resident in Thailand, and hence dependence on others for data collection. Livestock authorities do not always regard animal health information as a public good, for fear of jeopardising trade prospects. In such a context, probing questions on animal health expenditure tend not to be well accepted.

EXTENT OF INTEGRATION IN ACIAR PROJECT 9204
ACIAR project 9204 was a three-year project with a modest aim of trialing information technology in three northern provinces in Thailand, and little time was available to undertake integrated modelling. Curtailment of planned survey work in Thailand limited availability of data at the individual farm level. Some mapping of variables of economic interest was performed, although the higher forms of integration were not achieved. Further mapping - such as of "price surfaces" and livestock trade movement patterns - would have been useful from an economic perspective.

From the Thammasat database (of about 60,000 village records for Thailand) it was possible to map livestock numbers by species by district throughout Thailand, using the GIS. Cattle are relatively uniformly distributed, while pigs concentrate near Bangkok. This provided an indication of where concentrations are greatest and where control measures would be likely to be most rewarding. The GIS also provides maps of herd sizes, useful for designing samples of livestock within villages for active surveillance.

CONCLUDING COMMENTS
So far there has been little use of GIS to map economic data and to employ economics in conjunction with GIS of animal data to determine appropriate public responses to outbreaks of contagious animal diseases. Various opportunities exist for integration of the two methodologies in the generation of information for decision support. The more obvious involve spatial mapping of livestock density, outbreaks and vaccination coverage. At a more ambitious level, dynamic simulation of livestock populations, and production and health status, are technically possible. In Thai-Australia project, the GIS and economic components of the research have proceeded relatively independently and, as elsewhere, opportunities for integration of the two approaches have not been well exploited. A number of constraints on integration are apparent.

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