



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

*No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.*

# RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS

AN ACIAR THAI-AUSTRALIAN PROJECT

**Working Paper No. 31**

**The Thai Dairy Industry: Its Economic  
Evolution Raised by Land Rights and Cattle  
Diseases**

by

**Tatjana Kehren and Clem Tisdell**

**February 1997**



ISSN 1322-624X

**RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS**

**Working Paper No. 31**

**The Thai Dairy Industry: Its Economic Evolution and  
Problems Raised by Land Rights and Cattle Diseases<sup>1</sup>**

**by**

**Tatjana Kehren and Clem Tisdell<sup>2</sup>**

© All rights reserved

---

<sup>1</sup> This is a revised version of a paper presented at the 41st Annual Conference of the Australian Agricultural and Resource Economics Society on 'Agricultural and Resource Developments: Overcoming the Constraints' at the Pan Pacific Hotel, Gold Coast, January 20-25, 1997. We are grateful for useful comments received on this occasion. This paper has benefited from some financial support from ACIAR Project No. 9204.

<sup>2</sup> School of Economics, The University of Queensland, St. Lucia Campus, Brisbane QLD 4072, Australia  
Email: [c.tisdell@economics.uq.edu.au](mailto:c.tisdell@economics.uq.edu.au)

*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](mailto:c.tisdell@economics.uq.edu.au)) or Dr Steve Harrison, ([s.harrison@uq.edu.au](mailto:s.harrison@uq.edu.au)) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

# **The Thai Dairy Industry: Its Economic Evolution and Problems Raised by Land Rights and Cattle Diseases**

## **ABSTRACT**

Changes in the economic, demographic and political characteristics of Thailand have had a strong impact on the traditional nature of Thailand's agriculture and livestock industries over the last few decades. This paper outlines the development of the Thai dairy industry and discusses economic factors, including government policies, influencing its development. Land rights have affected its development, e.g. the availability of credit to dairy farmers. In addition, the small size of Thai farms and lack of a ready market in land has resulted in small herd sizes. Furthermore, the extensive use of common property resources has implications for resource management and sustainable agricultural development in Thailand. A number of environmental issues are considered, associated with raising dairy cattle and other livestock in Thailand. The growth of the Thai industry highlights the urgency of cattle disease control, especially the control or eradication of particular diseases. The policy implications of this are discussed.

**Keywords:** Livestock disease, dairy industry, Thailand, Land rights.

**JEL Classification:** Q15, Q16

# **The Thai Dairy Industry: Its Economic Evolution and Problems Raised by Land Rights and Cattle Diseases**

## **1. Overview**

During the past two decades, Thailand has experienced considerable increases in population and income levels which have resulted in a significant increase in demand for meat, milk and milk products. Despite considerable increases in local milk production, the accelerating demand for dairy products still exceeds the available local supply. Inadequate feed supplies and high production costs are constraints on Thai dairy farmers, resulting in low productivity and lost income. Inadequate property rights in Thailand limit the financial resources of farmers which is particularly important for dairy farmers due to the high capital intensity of this agricultural sector.

Extensive forest clearing for agricultural purposes has led to overgrazing of pastures, with farmers extensively using communal areas as fodder for their cattle and buffaloes. This has resulted in severe land degradation and other environmental consequences. Overgrazing has led to inadequate nutrition, low breeding performance and an increased susceptibility of animals to disease. Livestock diseases such as FMD are still endemic throughout Thailand and require control through effective use of vaccination and precautionary measures at the village level.

## **2. The Development of the Thai Dairy Industry**

Historically, milk was never an important product within the Thai culture, and hence the virtual non-existence of dairy cattle until the second half of this century. Traditionally, meat from cattle and buffalo herds was only obtained from retired working animals (Murphy and Tisdell 1995) and surplus income is gained by farmers through the sale of animals for slaughter purposes. In the 1950s, Indian settlers initiated dairying operations in Thailand, with Bangkok being the main market for their milk (Kehren and Tisdell 1996).

The commercial production of dairy cattle in Thailand commenced after the establishment of the Thai Danish Farm and Training Centre at Muek-Lek, which was a joint venture between the Thai and the Danish governments in the early 1960s (Pichet 1991). Another joint venture,

the Thai- German Dairy Training and Processing Plant was established in Chiang Mai in 1968, and taken over by the Thai Department of Livestock Development in 1977. Government promotion of milk consumption, in particular as a product for children, resulted in a slow but steady increase in demand throughout the 1970s (ADC 1993). Milk powder as a substitute for mother's milk now represents, in terms of value, a significant proportion of Thailand's milk imports (Chinwala and Umrod 1993).

Due to demand regularly exceeding local supplies at market prices, the Thai government established a programme in 1978 to rapidly boost local supply, but the programme had only limited success due to the high cost of local production relative to recombined milk made from cheaper imports. In response, the Thai government founded the Dairy Farming Promotion Organisation (DFPO) for the development of the local market for milk products as well as the promotion of milk production, and introduced restrictions on the import of fresh milk and milk powders in 1982 (ADC 1993). Imports of dairy products face a range of customs duties and other taxes, with customs duties ranging from 10 per cent of CIF value for milk powders to 60 per cent for cheese (ADC 1993). Apart from decreasing demand for particular market segments, these duties also generate substantial revenue for the Thai government. Table 1 summarises the rather high customs duties imposed by Thailand on dairy products.

**Table 1: Summary of Thailand's customs schedule for dairy products**

Dairy Product	Ad Valorem Duty Rate
AMF	25%
Butter	20 baht/kg or 60%*
Wholemilk Powder «	25%
Skim Milk Powder	25%
Cheese	
- natural	20 baht/kg or 60%*
- processed	20 baht/kg or 60%*
Condensed Milk »	25%

\* Whichever is the higher amount.

« WMP for infants, 10 per cent.

» Sweetened. For unsweetened, 40 per cent.

Source: ADC (1993), p.4

Apart from customs duties and taxes, local content requirements apply to imports of milk and milk substitutes (ADC 1993). For each kilogram of imported milk (or milk equivalent), at least two kilograms of locally produced raw milk have to be purchased, which means that at least twenty units of local milk must be purchased for each unit of imported milk powder used in recombined milk production.<sup>1</sup> These regulations ensure that imports of fresh milk are negligible, as imports of milk substitutes are only economic in conjunction with domestic processing operations. However, local content requirements have been eased in recent years, since the local demand for milk has by far exceeded the available local supply (ADC 1993).

During the 1980s, local milk production showed considerable growth (see Table 2) due to these government regulations. An estimate of Thailand's total raw milk output today is around 300,000 litres per day. The major provinces for milk production are Chiang Mai (in the North of the country), Nakhon Pathom, Ratchaburi and Saraburi (all in the Central Plain region). With rising local milk production, Thai dairy herd numbers also experienced a considerable increase, from 13,700 cows in 1982 to over 70,000 by 1990 (ADC 1993). However, the average size of Thai farms is still only about 6 cows, compared with about 30 in Sweden (Uhlin 1996) and 104 in Australia.

**Table 2: Milk production in Thailand from Plan 1 (1961) to 1990**

National Plan / Year	Milk Production (Tonnes)
Plan 1-4	Na
Plan 5	29,568.96
Plan 6	89,712.75
1988	106,708.85
1989	132,228.27
1990	163,850.66

Source: O.A.E. (1992), p.156

<sup>1</sup> In this context, ten kilograms of milk powder are classed as equal to one kilogram of milk equivalent. These regulations are rather complex. Even though ten kilograms of milk powder will in reality yield more than one kilogram of milk, the Thai government makes the theoretical assumption of ten kilograms of milk powder being equal to one kilogram of milk equivalent. With the local content regulation of having to purchase twice the amount of locally produced milk for every unit of imported milk or milk equivalent, Thai milk producers are encouraged to import milk powder rather than milk.



Thai dairy cattle have relatively low yields, averaging around 9 to 10 litres (per cow) a day. A much higher productivity is the case in Sweden, with around 17 to 18 litres (per cow) a day. A decrease in cow numbers by 45 per cent in Sweden between 1960 and 1990 resulted in 90 per cent of dairy farms closing, without a significant change in the country's total milk production, being at least partly due to increasing technical and scale efficiency (Uhlin 1996). Therefore, serious attempts should be made to enhance Thailand's milk production capacities by increasing scale and improving technical efficiency.

Despite the increase in local milk production, Thailand's milk supply is insufficient to meet the accelerating demand for milk and dairy products at 'acceptable' prices. Only about 20 per cent of dairy products are produced locally and around 80 per cent are supplied via imports. Between 1985 and 1990, aggregate consumption of milk products is believed to have risen from 400,000 to 700,000 tonnes, which is an increase of 75 per cent. In more recent years, this rate of growth has slowed, but still exceeds five per cent per annum in the drinking milk sector. This rapid increase in demand is a result of population growth, increased tourism and higher standards of living. However, milk producers in Thailand face various constraints that impede higher output and productivity levels.

Inadequate feed supplies and high production costs are amongst the most serious problems facing small farmers in Thailand. Low availability of forage and roughage leads to the wide use of concentrates which account for almost 60 per cent of the on-farm variable costs of production (Kehren and Tisdell 1996). Furthermore, overgrazing of pastures and insufficient funds to purchase improved breeds of dairy cattle have resulted in low productivity and widespread infertility of dairy cows. Improvements in feeding and nutrition are crucial for higher milk production levels in Thailand.

### **3. Land Rights in Thailand**

Property rights in land have been a controversial issue in many countries, including Thailand. Land used to be abundant in Thailand, but forest depletion has occurred over the last thirty years largely as a consequence of extensive clearing of land for commercial agriculture. Private returns to land clearing for commercial production were sufficient to allow a large expansion in the area under cultivation. A repeated long-distance migration of settlers into reserved forests was a frequent response to shortages of arable land in Thailand. When Thailand's population size was small, the Thai government paid little attention to formal

ownership registration of land (Feder 1987).<sup>2</sup>

As a consequence of the opening of Thailand to international trade, incentives for production expansion increased significantly and resulted in a growing demand for a more secure form of land ownership (Feeny 1982). Due to a gradual increase in the degree of commercialisation of the Thai economy in the first half of the nineteenth century, individual land rights were formalised in the second half of the nineteenth century through the issuance of title deeds. A number of amendments to this legislation took place in order to end frequent land disputes and new laws on land rights were enacted.<sup>3</sup> However, land could not be unambiguously identified due to a lack of precise descriptions of land boundaries and negligent record keeping. The present system of land rights in Thailand is based on the 1954 Land Code which recognises individual ownership of specific tracts of land, allowing the owner unrestricted sale, transfer and mortgaging.

The implementation of this legislation and the gradual evolution of private property rights has not been without problems. As Feeny (1988) explains, all land not claimed within 180 days of the passing of the 1954 Act was supposed to become property of the government. Yet, local administration officials have allowed villagers to continue to file claims for newly cleared areas. Moreover, there is widespread evasion of forestry regulations, as publicly managed forests are exploited for commercial purposes.

Due to deficiencies in the Thai property rights system and its administration and enforcement, private parties are encouraged to overexploit forest resources. These problems occur because of a divergence between the private and social rates of return. Actual practice indicates that many legal and illegal exceptions were made, where local practice overrode national conservation policy.<sup>4</sup> It is estimated that today at least 1.2 million families (which is -20 per cent of Thai farmers) inhabit about one-fifth of the land officially classified as forest reserves (Feder 1987, Hirsch 1990). A further problem is the creation of negative externalities, as some of the costs of land clearing are not borne by the people who are responsible for them. This is particularly so of erosion, flooding and silting.

Traditionally, village life in Thailand was based on kinship systems and communal

---

<sup>2</sup> Interestingly, when labour was scarce and land abundant, property rights in labour were often defined with much greater precision than property rights in land. In the early nineteenth century, slaves rather than land served as collateral in financial markets.

<sup>3</sup> See Thomson, Feeny and Oakerson (1992) for a detailed description of the various legislations.

<sup>4</sup> For examples of these practices, see Feeny (1988).

structures.<sup>5</sup> In the North of the country (which is subject to persistent depletion of public forests, to watershed damage and increased industrial activities) collective management of forest and water resources at the village level date back to the nineteenth century (Christensen and Rabibhadana 1994). Although several unwritten principles of land inheritance exist, disputes among relatives over inherited land also arose. According to Ganjanapan (1994), these disputes have increased since the government asked villagers to turn their land documents into title deeds. Landholdings under the system of traditional practices which emphasized the usufruct rights of kinship group members were believed to be secure.<sup>6</sup> Disputes now, however, frequently seem to be over inherited land and arise from conflicts between legal and traditional principles of practices.

One of the most crucial disputes stems from the villagers' desire or need to use the land document as collateral. Improved access to institutional credit is one of the major advantages of secure, legally documented land ownership. Inadequate surveying and record keeping have resulted in about 17 million parcels of land in the country not being registered on land title deeds (Jones 1993). Most of the Thai farmers living in state-owned, forest reserve areas have had de facto possession of the land for many years and consider it their land. Most of them have also been paying taxes which they regard as implicit official recognition of their ownership. However, this is not the case and Thai farmers living in forest reserves do not possess any property rights in land, even if they have lived there for decades. Since these farmers, who are frequently termed 'squatters', cannot legally claim ownership of the land, they do not have any protection against eviction to enforce forest reserve boundaries and cannot use their land as loan collateral.

While the eviction risk has been rather low in Thailand (Feder 1987, Feder and Feeny 1991), the limited access to credit is a more serious problem. Formal credit institutions do not accept land as collateral without formal title, but without being able to use their land as loan collateral, squatters' access to medium- and long-term credit from formal institutions is very restricted. Studies have shown that titled farmers frequently use their land as loan collateral, obtaining significantly larger amounts of institutional credit.

Apart from limited borrowing capacity, an obvious consequence of lack of land ownership is

---

<sup>5</sup> For further details regarding traditional land transfer in villages in Northern Thailand, see Ganjanapan (1994).

<sup>6</sup> Ganjanapan (1994) describes in detail this system of traditional practices and the difficulties encountered in the conversion of land documents to title deeds.

increased uncertainty with respect to farmers' benefits from investments for the purpose of improving the farm's productive capacity (Feder 1987). An exception might be the case when agricultural development has not progressed much and land rights are regulated by emerging customs and norms, reducing the uncertainty to some degree. However, with new technology and increased commercialisation, uncertainty is likely to rise again (as a consequence of land disputes).

A study by Feder (1987) supported the hypothesis that ownership insecurity due to limited access to credit and a lack of investment incentives leads to lower farm productivity.<sup>7</sup>

Limited financial resources are also a problem for dairy farmers in Thailand. Limited financial resources of small farmers do not allow the purchase of adequate numbers of improved breeds of dairy cows. Most small farmers do not have sufficient property as collateral for a bank loan, and dairy cattle are more expensive than other cattle. A difference in price exists between local and improved types of breeds, with improved breeds fetching a considerably higher price. Tables 3 and 4 illustrate the different prices and values of various types of dairy buffaloes and dairy cattle in Thailand, gathered from a survey of 200 small farm households from 17 provinces throughout the country (Thummabood and Morathop 1993).

---

<sup>7</sup> Feder (1987) tested this hypothesis by using farm level data from three provinces in Thailand. The results of his econometric analysis showed that titled farmers used significantly higher quantities of variable inputs and obtained higher crop output per unit of land in two of the provinces, whereas in the third province, titled ownership was of lesser significance. The reason for this was that the non-institutional credit market (where collaterals and titles are less important) was well developed in this province, compared with the other provinces studied.

**Table 3: Buffalo in Thailand – Survey Results**

Types of animal	% of farms	Local breed (%)	Improved breed (%)	Number of animal (head) per farm	Price per head (\$US)	Total value (\$US)
Young stock						
young male	19	100	0	2	170.2	262.2
young female	20	100	0	2	178.3	319.24
Adult						
breeder bulls	15.9	10	0	2	364.7	709.4
draught males	14.9	94	6	2	373.8	620.0
dairy cows	5.6	17	83	2	396.6	733.3
dried cows	1.0	100	0	1	320.0	320.0
draught cows	24.3	100	-	2	300.6	582.2
Average	100	88	12	2	276.0	499.6

Source: Thummabood and Morathop (1993), p. 34

**Table 4: Dairy Cattle in Thailand – Survey Results**

Types of animal	% of farms	Local breed (%)	Improved breed (%)	Number of animal (head) per farm	Price per head (\$US)	Total value (\$US)
Young stock						
young male	22.8	16	84	3	171.4	691.1
young female	33.7	13	87	3	237.4	898.6
Adult						
breeder bulls	16.8	24	76	4	416.9	1,702.9
draught males	2.3	29	71	8	232.0	2,152.0
dairy cows	14.2	0	100	5	791.9	4,202.7
dried cows	6.6	0	100	3	814.1	3,625.9
draught cows	3.6	30	70	4	407.6	1,512
<b>Average</b>	<b>100.0</b>	<b>16</b>	<b>84</b>	<b>4</b>	<b>375.3</b>	<b>1,686.5</b>

Source: Thummabood and Morathop (1993), p. 35

As can be seen from these tables, the price of both dairy buffaloes and dairy cattle is the highest of all types of livestock. The average number of dairy buffalo per dairy farm was 2, whereas it was 5 for dairy cattle. On average, 14.2 per cent of farmers in this survey raised milking cattle and 6.6 per cent kept dry cows, all of which were improved breeds. It is believed that Thai small farmers raise cattle for family income and buffaloes for draught purposes. According to the survey, the number of cattle purchased has risen, probably due the comparatively higher value of cattle and the decreasing importance of buffalo as draught animal.

#### 4. Sustainable Agricultural Development and Environmental Issues

Deforestation is one of the most serious environmental problems for Thailand. The country's forest area declined from 58 per cent of its total land area in 1960 to only 28 per cent (14.3 million ha) by 1988 (Onchan 1993). Extensive forest clearing took place particularly during the 1970s, and forest land is still diminishing, despite a national ban on logging since 1989. Nationwide infrastructure investments contributed to the large-scale destruction of forests, and over the last three to four decades, the clearing of forest for agriculture resulted in a serious decline in land availability. The expansion of crop land into upland areas has reduced available grazing land and resulted in overgrazing of pastures.

With diminishing pastures, farmers let their cattle graze on the harvested paddy fields in the dry season and along roadsides, on edges of cultivated plots and in forest reserves and other common property or open-access land during the wet season which is the crop growing season. Around 70 per cent of feed supplies for buffalo and cattle are obtained from communal areas (Thummabood and Morathop 1993). The consistency and quality of feed supplies for livestock can, to a large degree, be affected by fluctuating climatic conditions (Murphy and Tisdell 1996). Based on a survey of 135 farm households in Northern Thailand (ACIAR 1994), almost 60 per cent of grazing during the wet season occurs on communal fields (Murphy and Tisdell 1996), and forests are the most important source of feed supplies during that time (see Table 5).

**Table 5: Grazing of cattle and buffaloes in Thailand**

Season		Public Pasture	Forest	Mountain	Near Water	Roads	Total
Cool	No*	2	12	6	0	3	23
	%	1.5	8.9	4.4	0	2.2	17
Hot	No*	0	7	1	4	0	12
	%	0	5.2	0.7	3	0	8.9
Wet	No*	5	56	13	0	3	77
	%	3.7	41.5	9.6	0	2.2	57

\* Number of families reporting

Source: Based on ACIAR (1994)

Small farmers living in rural areas of Thailand usually practise an integrated farming system, consisting of crops, fishery, horticulture and livestock. Traditionally, the livestock sector has played a complementary, yet substantial role to the subsistence economy by providing additional income and employment opportunities. Cattle (dairy and non-dairy), buffaloes, pigs and poultry are the major types of livestock raised by small farmers in Thailand.<sup>8</sup>

Village livestock are raised in traditional ways in Thailand. While only a small percentage of poultry are confined at night, most cattle and buffaloes are kept under or around the house at night. During the day, most of the poultry are free roaming and many Thai farmers raise them as stray chickens. While women in Thailand usually take care of pigs and poultry, they fulfill fewer duties for the raising and feeding of cattle and buffaloes which are mainly looked after by the males in the household. Dairy cattle are usually managed under stall feeding systems. Milking cows are kept in the milking barn almost all the time, and dry cows and heifers are kept in shady areas, whereas calves are confined together in small cages or milking barns (Kehren and Tisdell 1996).

Most of the dairy cows are fed with roughages harvested from along the roadside and farmers frequently have to leave their village to find feed for their cattle and buffaloes. They might travel up to 100 kilometres to collect green and dry fodder from communal lands, amounting to around 70 per cent of the animal feed (Thummabood and Morathop 1993). Consequently, overgrazing of communal land has resulted in inadequate nutrition and thereby low breeding performances as well as an increased susceptibility of animals to disease.

Land as an ecosystem is significant in the context of resource management for sustainable development. Land use through crop production has an effect on the soil fertility and thereby on the productivity of the land. In the case of Thailand, the problem of natural resource deterioration has been recognised since the 1960s, and in 1980, it was estimated that over 25 per cent of the total land area had been severely affected by soil erosion, due to deteriorated forest in the uplands (Onchan 1993, Saenjan 1993). This has serious consequences such as droughts, uncontrollable flooding and sedimentation of reservoirs.

Moreover, major land types in Thailand have not been utilized according to their suitability,

---

<sup>8</sup> Sheep and goats are commonly raised by Muslims in the South of Thailand.



and more and more poorly-suited land, such as marginal agricultural land<sup>9</sup>, has been used for agricultural purposes (Wattanasarn 1993). Six problem soils have been identified by the Department of Land Development in Thailand which constitutes 56 per cent of the country's area<sup>10</sup> and research has been initiated for an improvement of these soils.

As a response to Thailand's severe land degradation, a significant proportion of forestry and land resources have been set aside for protection. Twenty-five per cent of Thailand's total land area is reserved for the conservation of forests. Nevertheless, this has not prevented poor farmers from encroaching on forest lands, contributing to natural resource degradation and inhibiting sustainable agricultural development.

Attempts have been made by the Thai government to reverse resource degradation through a variety of programmes, including reforestation, conservation and land development. Although programmes for forest protection and appropriate land use have been implemented for many years, they have had limited success.

A further issue related to the Thai environmental difficulties is the use of highlands, in particular by hilltribes. Many hilltribes live in the mountains in Northern Thailand and recently, vegetable (mainly cabbage) planting has become popular due to good market demand and high prices. The use of chemical fertilizers and pesticides has resulted in water pollution in the lowland areas. This type of problem is not confined to hilltribes, however, as many farmers do not understand the possible detrimental impact of chemical applications (Onchan and Arunpoo 1991).

Integrated crop-livestock systems are implemented by the majority of small farmers in Thailand and extensive forest clearing for increased agricultural activities has had serious implications for farmers raising livestock. Natural resource depletion and environmental degradation have been the results of forest clearing, over-exploitation of natural resources and over-use of chemicals. The interdependence of these factors has to be realized for an effective strategy to solve the country's environmental problems and achieve sustainable agricultural development.

---

<sup>9</sup> Marginal agricultural land is land consisting of problem soil which imposes severe limitations on profitable crop production through its physical and chemical characteristics. Soils defined as problem soils are generally not suitable for agriculture (Bhubharuang 1993).

<sup>10</sup> For further details, see Wattanasarn (1993).

## 5. Cattle Disease Control and its Policy Implications

The occurrence of animal health diseases has significant implications for livestock production and trade (Tisdell 1994). In rapidly developing countries such as Thailand, livestock diseases result in significant costs at the private as well as the national level. It is important to identify the effect of a disease on production in order to estimate the benefits of a disease control programme (Ellis and James 1979).

Infectious diseases reduce production levels and thereby the income of farmers. They can also limit the export of livestock products. Outbreaks of infectious diseases are quite common in rural Thailand. Moreover, infectious diseases can either occur once and the animal will then be immune against the next outbreak, or they can occur several times, as is the case with foot-and-mouth disease (FMD). With the growing commercialisation of the cattle industry in Thailand, the importance of elimination or at least control of animal diseases also increases.

Diseases of dairy cattle can be classified into three categories<sup>11</sup>: acute infectious diseases, such as FMD which are followed by recovery or death. In case of recovery, serious secondary bacterial diseases can delay the recovery process and affect lactation. The second types of diseases are chronic diseases, for instance mastitis. These reduce production levels as well as the quality of the milk. Reproductive disorders, such as brucellosis which can lead to abortion and infertility, are the third kind of dairy cattle diseases.

In Thailand, three types of FMD virus were reported during the 1950s and are still endemic throughout the country except in the Southern area, even though control measures for FMD have been implemented since 1956. Table 6 demonstrates details about recent numbers of outbreaks of various types of the FMD virus in Thailand and the number of animals affected. A significant number of outbreaks still stems from one or several unknown virus strains. FMD spreads easily by contact, air and residues.

---

<sup>11</sup> The authors are grateful to Gavin Ramsay for his ideas and comments on this issue.

**Table 6 – Foot and Mouth Disease Outbreaks in Thailand in 1992**

Type	No. of Outbreaks	No. of Cattle Affected	No. of Buffaloes Affected	No. of Pigs Affected
O	54	16,599	7,044	185,685
A	14	5,527	1,476	-
Asia 1	89	30,340	9,854	21,676
Unknown *	39	31,207	4,369	25,491

\* Old lesions; virus difficult to isolate or sample was too small.

Source: Hanyanum et. al. (1994), p. 193

Because Thailand is bordered by four countries, it has been very difficult for the government to control the spread of diseases by animal movement into the country, often transmitted by smuggling animals across the border (Chaisrisongkram 1994, Hanyanum et al. 1994). Furthermore, spread from surrounding villages is an important source of FMD outbreaks, as livestock mingle while grazing or sharing common water sources (Baldock et al. 1994). A further source of outbreaks is through introduction of infected animals from a market.

Maintaining the health of dairy cattle in Thailand can be expected on the whole to be economically more important than maintaining the health of other types of cattle for various reasons. As previously mentioned, the price per head of dairy cattle exceeds the price of all other types of cattle (Thummabood and Morathop 1993). Therefore, any mortality involves greater value foregone than for other cattle. Since all the Thai dairy herds consist of improved breeds, they are liable to be more susceptible to local diseases than local breeds.

Moreover, the productivity of dairy cattle is more susceptible to disease than is the case for animals kept for meat or draught purposes. Milk production in a dairy herd is dependent on regular calving by cows. Diseases such as FMD can induce delayed contraception or abortion, resulting in a loss of income from milk as well as fewer calves available for rearing or sale. This can have a substantial effect on the income of Thai dairy farmers. Furthermore, after some diseases, dairy cattle either cease lactating or have much reduced yield in that lactation.

With some diseases such as FMD, secondary health complications can result in greater economic loss than the prime disease. In the case of FMD, mastitis frequently follows, causing permanent scarring of the mammary glands and thus reduces the future milk

production of the animal. Foot lesions (which restrict the animal's grazing area) and mouth lesions (which make eating painful) from FMD can also contribute to a decline in future milk production (James and Ellis 1978).<sup>12</sup> By comparison, most economic losses with beef or draught cattle from many diseases such as FMD (compared to dairy cattle) tend to be transitory. In local breeds in Thailand, mortality from FMD is very low. Weight loss occurs for a period and animals are too weak for draught purposes, but recovery can be rapid. Some economic loss occurs but the disease is of less economic importance than in dairy cattle.

Little systematic sustained study of the economics of controlling cattle diseases in Thailand has been undertaken because it is difficult to collect relevant basic data and the Thai Department of Livestock and Development has no tradition of employing economists. In particular, foreigners are likely to be at disadvantage in collecting information because of language and cultural barriers as well as possible suspicion about the use to be made of the information. However, Bartholomeus and Culpitt (1992) did a rapid appraisal for Northern Thailand of the benefit-cost ratio of increasing the extent of vaccination coverage of cattle against FMD from the existing coverage of 70 per cent to 90 per cent. 'Heroic' assumptions were required to complete this analysis and these could affect its realism. Ellis (1994) has elaborated on the method used. Unfortunately, the estimate of Bartholomeus and Culpitt only relates to cattle kept for beef and does not address costs and benefits of control of FMD in relation to Thai dairy cattle, nor for that matter, pigs.

Considering the previously outlined aspects of animal health diseases of Thai cattle, the following policy implications can be drawn: With increasing dairy cattle numbers and use of improved breeds, Thailand needs for economic reasons to give increasing attention to the control or eradication of FMD. The veterinary costs of keeping dairy cattle are likely to be higher than for non-dairy cattle. On economic grounds, all dairy cattle should be vaccinated against FMD.

Since FMD viruses can be carried in milk this provides an additional reason why all dairy cattle should be vaccinated against such viruses. In the case of dairying, the scope for external effects from FMD is enhanced. In addition, all breeds used for dairying in Thailand are imported improved ones and these are more susceptible to FMD. Effective vaccination

---

<sup>12</sup> Schepers and Dijkhuizen (1991) emphasise the necessity of analysing the reliability and consistency of economic estimates of disease controls. Their paper is an analysis of studies calculating the losses of mastitis and profitability of mastitis control since 1970. Only four papers were found that calculated the total economic impact of mastitis and the only item included in the estimates of all papers was changes in milk production.

requires that the proportion of the herd vaccinated must be as high as possible and that there is as little variation in vaccination coverage between villages as possible (Cleland et al. 1994).

Further training of Thai farmers regarding the treatment of animal diseases is another possible means for a reduction of livestock diseases. Due to a lack of knowledge, farmers frequently cannot treat livestock diseases adequately, resulting in the spread of disease and consequential loss of income. Although training courses for livestock farmers exist and district livestock extension officers provide training on livestock technology, the number of technical personnel is insufficient (Thani et al. 1996, Thummabood and Morathop 1993). The Department of Livestock Development could increase their support to Thai farmers through an extension of training in livestock raising and disease control.

The shared use of common resources is one of the major causes of the spread of FMD. Provision of independent water supplies - if possible - could reduce the frequency of FMD outbreaks. In addition, quarantine of early cases during outbreaks could significantly diminish the incidence of FMD through reduced spread within the village concerned, as well as among villages (Cleland et al. 1996). Since most of the benefits from disease control programmes tend to remain in the rural sector, there is more incentive for farmers to cooperate in the implementation of a programme and possibly reinvest the benefits (James and Ellis 1978).

## **6. Concluding Comments**

Significant increases in income and population levels in Thailand over the last two decades have resulted in local demand for milk and milk products consistently exceeding the available local supply. Various constraints exist on Thai dairy farmers limiting their production capacities, and government regulations were imposed on imports of dairy products in order to support domestic milk production.

Uncertainty regarding land ownership and the deficiencies in the enforcement of the Thai property rights system are still significant problems for farmers. Dairy cattle are more expensive than other cattle and limited financial resources prevent Thai farmers from acquiring improved breeds of dairy cows. Moreover, without title deeds, land cannot be used as collateral for a bank loan.

Extensive forest clearing, overgrazing of pastures and increased use of communal areas for the grazing of cattle have resulted in severe deforestation in Thailand. Communal land use has produced serious natural resource deterioration and has discouraged investment in pasture improvement. Apart from a number of environmental problems, infectious livestock diseases are quite common in Thailand. Communal grazing and watering of livestock assists the spread of contagious livestock diseases such as FMD. The importance of elimination or control of acute infectious diseases such as FMD is important for Thai dairy farmers. Increases in local milk production can only occur if the health of cattle is maintained through adequate prevention and control measures, including effective vaccination programmes.

## 7. References

- Australian Centre for International Agricultural Research (ACIAR) (1994) *Thai-Australian Animal Health Project Cross Sectional Village Survey*, Bangkok.
- Australian Dairy Corporation (ADC) (1993) *Thailand, Dairy Market Briefings*, ADC, Victoria.
- Ayuwat, D. (1993) "Effects of Migration Patterns on Forest Use and Forestry Projects in a Thai Village", *Society and Natural Resources*, **6**, 195-202.
- Baldock, F.C., Cleland, P.C., Chamnanpood, P. and L.J. Gleeson (1994) "Factors Affecting the Risk of Foot-and-Mouth Disease Outbreaks in Northern Thai Villages", pp. 26-32 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) (1994) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, Thailand, 6th- 9th September 1993, ACIAR Proceedings No. 51, Canberra.
- Bartholomeus, B. And R. Culpitt (1992) *An Economic Study of Foot and Mouth Disease Control in Three Selected Provinces in Northern Thailand: First Report*, Economic Services, Department of Primary Industries Queensland, Brisbane.
- Bhubharuang, B. (1993) "Thailand (2)", pp.223-233 in *Development of Marginal Agricultural Land in Asia and the Pacific*, Report of an APO Seminar, 20th-29th April 1992, Bangkok, Asian Productivity Organization, Tokyo.

- Chaisrisongkram, W. (1994) "An Overview of Foot-and-Mouth Disease Control in Thailand", pp.23-25 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) (1994) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, Thailand, 6th- 9th September 1993, ACIAR Proceedings No. 51, Canberra.
- Chaiwanakupt, S. and C. Changprai (1991) "Resources and Problems Associated with Sustainable Development of Uplands in Thailand", pp.62-69 in Blair, G. And R. Lefroy (eds.) *Technologies for Sustainable Agriculture on Marginal Uplands in Southeast Asia*, Proceedings of a Seminar Held in the Philippines, 10-14 December 1990, ACIAR Proceedings No.33, Canberra.
- Chinwala, A. and S. Umrod (1993) "Thailand", pp.355-372 in *Dairy Farming in Asia*, Report of an APO Study Meeting, 26 July - 6 August 1988, Tokyo, Asian Productivity Organization, Tokyo.
- Christensen, S.R. and A. Rabibhadana (1994) "Exit, Voice, and the Depletion of Open Access Resources: The Political Bases of Property Rights in Thailand", *Law and Society Review*, **28** (3), 639-656.
- Cleland, P.C., Baldock, F.C., Chamnanpood, P. and L.J. Gleeson (1996) "Village Level Risk Factors for Foot-and-Mouth Disease in Northern Thailand", *Preventive Veterinary Medicine*, **26** (3) 253-261.
- Cleland, P.C., Baldock, F.C., Gleeson, L.J. and P. Chamnanpood (1994) "A Modelling Approach to the Investigation of Vaccination Strategies for Foot and Mouth Disease in Thailand", *The Kenya Veterinarian*, Proceedings of the 7th International Symposium on Veterinary Epidemiology and Economics, Nairobi, 15th-19th August 1994, **18** (2), 394-397.
- Ellis, P.R. and A.D. James (1979) "The Economics of Animal Health- (1) Major Disease Control Programmes", *The Veterinary Record*, **105**, 504-506.
- Ellis, P.R. (1994) "The Economics of Foot-and-Mouth Disease Control", pp. 57-68 in J.W. Copland, L.J. Gleeson and P. Chamnanpood (eds.) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Australian Centre for International

Agricultural Research, Canberra, ACT.

- Feder, G. (1987) "Land Ownership Security and Farm Productivity: Evidence from Thailand", *The Journal of Development Studies*, **24** (1), 16-30.
- Feder, G. and D. Feeny (1991) "Land Tenure and Property Rights: Theory and Implications for Development Policy", *The World Bank Economic Review*, **5** (1), 135-153.
- Feder, G. and T. Onchan (1987) "Land Ownership Security and Farm Investment in Thailand", *American Journal of Agricultural Economics*, **69** (2), 311-320.
- Feder, G., Onchan, T. and Y. Chalamwong (1988) "Land Policies and Farm Performance in Thailand's Forest Reserve Areas", *Economic Development and Cultural Change*, **36** (3), 483-501.
- Feeny, D. (1988) "Agricultural Expansion and Forest Depletion in Thailand, 1900-1975", pp. 112-143 in Richards, J.F. and R.P. Tucker (eds.) *World Deforestation in the Twentieth Century*, Duke University Press, Durham/London.
- Feeny, D. (1982) *The Political Economy of Productivity: Thai Agricultural Development 1880-1975*, University of British Columbia Press, Vancouver.
- Ganajanapan, A. (1994) "The Northern Thai Land Tenure System: Local Customs versus National Laws", *Law and Society Review*, **28** (3), 609-622.
- Gleeson, L.J., Chamnanpood, P., Cheunprasert, S., Srimasartitkol, N. and A. Trisasarom (1995) "Investigation of an Outbreak of Foot-and-Mouth Disease in Vaccinated Dairy Cattle in Thailand", *Australian Veterinary Journal*, **72** (1), 21-24.
- Hayanum, W., Awaiyawanon, K., Wongdee, R. and P. Musikul (1994) "Thailand", pp.191-196 in Copland, J.W., Gleeson, L.J. and C. Chamnanpood (eds.) (1994) *Diagnosis and Epidemiology of Foot-and-Mouth Disease in Southeast Asia*, Proceedings of an International Workshop Held at Lampang, Thailand, 6th- 9th September 1993, ACIAR Proceedings No. 51, Canberra.
- Hirsch, P. (1990) "Forests, Forest Reserve, and Forest Land in Thailand", *The Geographical Journal*, **156** (2), 166-174.



- James, A.D. and P.R. Ellis (1978) "Benefit-Cost Analysis in Foot and Mouth Disease Control Programmes", *British Veterinary Journal*, **134** (1), 47-52.
- Jones, D. (1993) "Mapping Thailand's Future", *Focus*, March, 24-25.
- Kehren, T. and C.A. Tisdell (1996) "Women and Common Property Resources in the Management and Health of Livestock in Thai Villages", *Research Papers and Reports in Animal Health Economics* No.10, The University of Queensland, Brisbane.
- Kemp, J.H. (1981) "Legal and Informal Land Tenures in Thailand", *Modern Asian Studies*, **15** (1), 1-23.
- Manidol, C. and S. Chantkam (1986) "Feed Resources for Small Holder Dairy Production", *Extension Bulletin No.236*, ASPAC Food & Fertilizer Technology Centre, June 1986, pp.1-16.
- Murphy, T. and C.A. Tisdell (1995) "Specific Livestock Industries, Livestock Diseases and Policies in Thailand: An Overview of Bovines (Buffalo/Cattle)", *Research Papers and Reports in Animal Health Economics* No.10, The University of Queensland, Brisbane.
- Murphy, T. And C.A. Tisdell (1996) "Village Livestock and Disease Control in Northern Thailand: a Survey Examining Socio-Economic Factors", *Asia-Pacific Journal of Rural Development* **VI**(1), 47-70.
- Office of Agricultural Economics (O.A.E.) (1992) *Agriculture in Thailand* (in Thai and English), O.A.E., Bangkok.
- Onchan, T. (1993) "Land Use, Conservation and Sustainable Land Management in Asia", pp. 13-30 in *Rural Land Use in Asia and the Pacific*, Report of an APO Symposium, 29<sup>th</sup> September- 6th October 1992, Tokyo, Asian Productivity Organization, Tokyo.
- Onchan, T. and C. Arunpoo (1991) "Economic Aspects of Sustainable Land Management: Thailand's Experience", *Evaluation For Sustainable Land Management in the Developing World*, Vol. 2, International Board for Soil Research and Management, IBSRAM Proceedings No.12 (2), Bangkok.
- Pichet, S. (1991) "The Development of Dairy Farming in Thailand" in Speedy, A. and R. Sansoucy (eds.) (1991) *Feeding Dairy Cows in the Tropics*, Proceedings of the FAO

Expert Consultation held in Bangkok, 7-11 July 1989, FAO Animal Production and Health Paper No. 86, FAO, Rome.

Pookpakdi, A. (1992) "Sustainable Agriculture for Small-Scale Farmers: A Farming Systems Perspective", pp.6-17 in *Food and Fertilizer Technology Centre for the Asian and Pacific Region, Sustainable Agriculture for the Asian and Pacific Region*, ASPAC, Taipei.

Regier, H.A., Mason, R.V. and F. Berkes (1989) "Reforming the Use of Natural Resources", pp. 110-126 in F. Berkes (ed.) *Common Property Resources*, Belhaven Press, London.

Saenjan, V. (1993) "Rural Land Use in Thailand", pp.367-383 in *Rural Land Use in Asia and the Pacific*, Report of an APO Symposium, 29th September- 6th October 1992, Tokyo, Asian Productivity Organization, Tokyo.

Schepers, J.A. and A.A. Dijkhuizen (1991) "The Economics of Mastitis and Mastitis Control in Dairy Cattle: A Critical Analysis of Estimates Published Since 1970", *Preventive Veterinary Medicine*, **10**, 213-224.

Tan-Kim-Yong, U. (1992) "Participatory Land-Use Planning for Natural Resource Management in Northern Thailand", *ODI Rural Development Forestry Network*, Paper 14b, Winter.

Thani, P., Aphichatsarangkoon, T., Aekasing, B. and L. Worachai (1996) "Socio-economic Status and Animal Disease Prevention and Treatment" Research Paper, Chiang Mai University, October 1996.

Thomson, J., Feeny, D. and R. Oakerson (1992) "Institutional Dynamics: The Evolution and Dissolution of Common Property Resource Management", pp.129-160 in D.W. Bromley (ed.) *Making the Commons Work*, ICS Press, San Francisco.

Thummabood, S. and S. Morathop (1993) *Livestock as a Component of Rural Development of Thailand*, Department of Livestock Development, Thailand.

Tisdell, C.A. (1994) "Animal Health and the Control of Diseases: Economic Issues with Particular Reference to a Developing Country, *Research Papers and Reports in Animal Health Economics* No.2, The University of Queensland, Brisbane.

Uhlen, H.-E. (1996) "Structural Change in Swedish Agriculture", Presentation given at the University of Queensland on 17th October 1996, Brisbane.

Vandergeest, P. and N. L. Peluso (1995) "Territorialization and State Power in Thailand", *Theory and Society*, 24 (3), 385-426.

Wattanasarn, C. (1993) "Thailand (1)", pp.214-222 in *Development of Marginal Agricultural Land in Asia and the Pacific*, Report of an APO Seminar, 20th-29th April 1992, Bangkok, Asian Productivity Organization, Tokyo.

## ANIMAL HEALTH ECONOMICS

### WORKING PAPERS IN THIS SERIES

1. Assessing Public Programmes for Control of Animal Diseases in Developing Countries: General Economic Issues with Thai Examples – An extended ISVEE Paper by C. A. Tisdell, S. Harrison and F. C. Baldock, August 2004.
2. Animal Health and the Control of Diseases: Economic Issues with Particular Reference to a Developing Country by C. A. Tisdell, September 1994.
3. Assessing the Approach to Cost-Benefit Analysis of Controlling Livestock Diseases of McInerney and Others by C. A. Tisdell, May 1995.
4. The Economics of Vaccinating or Dosing Cattle Against Disease: A Simple Linear Cost Benefit Model with Modifications by C. A. Tisdell and G. Ramsay, May 1995.
5. Livestock, The Environment and Sustainable Development with Illustrations of Issues from Thailand by C. A. Tisdell and S. Harrison, June 1995.
6. The Use of Serology to Produce Disease Information for the Economics Analysis of Disease in Extensively Grazed Cattle by G. C. Ramsay, R. J. Dalgliesh, F. C. Baldock and C. A. Tisdell, September 1995.
7. The Role of Animal Health Programmes in Economic Development by S. Harrison and C. A. Tisdell, October 1995.
8. Trends in the Thai Livestock Industry, Animal Health Implications and Thailand's Development: An Introduction by T. Murphy and C. A. Tisdell, October 1995.
9. Specific Livestock Industries, Livestock Diseases and Policies in Thailand: An Overview of Bovines (Buffalo/Cattle) by T. Murphy and C. A. Tisdell, October 1995.
10. Overview of Pigs and Poultry: Specific Livestock Industries, Livestock Diseases and Policies in Thailand by T. Murphy and C. A. Tisdell, December 1995.
11. Livestock and Livestock Health in Northern Thailand: A Socio-Economic Analysis of a Cross-Sectional Survey of Villages by T. Murphy and C. A. Tisdell, March 1996.
12. A Review and Extension of Economic Pest Control Model Incorporating Multi-Pest Species and Insect Resistance by R. Davis, April 1996.
13. Foot and Mouth Disease: An Overview of its Global Status, Control Policies and Thai Case by T. Murphy, August 1996.
14. An Overview of the Status of Cattle Tick *Boophilus microplus* in Queensland by R. Davis, August 1996.
15. A Review of the Economics of Controlling Diseases in Livestock and the Modelling of Control Policies by T. Murphy, August 1996.
16. Optimal Livestock Disease Control Models and Their Possible Application to Thailand by T. Murphy, August 1996.
17. An Overview of Trends in Development in the Thai Dairy Industry by T. Murphy and C. Tisdell, September 1996.
18. Cost-Benefit Analysis with Applications to Animal Health Programmes: Basics of CBA by S. Harrison, September 1996.
19. Cost-Benefit Analysis with Applications to Animal Health Programmes: Complexities of CBA by S. Harrison, September 1996.
20. Cost-Benefit Analysis with Applications to Animal Health Programmes: Spreadsheet Implementation of Discounted Cash Flow and Risk Analysis by S. R. Harrison, September 1996.
21. Cost-Benefit Analysis with Applications to Animal Health Programmes: Allowing for Project Risk in CBA in S. R. Harrison, October 1996.

22. Cost-Benefit Analysis with Applications to Animal health Programmes: Valuation of Non-Market Costs and Benefits by S. R. Harrison, October 1996.
23. Cost-Benefit Analysis with Applications to Animal Health Programmes: Animal Health Programmes and Information Systems by S. R. Harrison, October 1996.
24. Women and Common Property Resources in the Management and Health of Livestock in Thai Villages by T. Kehren and C. A. Tisdell, November 1996.
25. Animal Health Information Systems by G. Ramsay, November 1996.
26. Collecting Animal Health Data for Cattle Properties in Extensive Grazing System by G. Ramsay, November 1996.
27. Sampling Considerations for Active Surveillance of Livestock Diseases in Developing Countries, November 1996.
28. On the Economics of Maintaining the Health of Livestock with Thai Examples by C. A. Tisdell, November 1996.
29. Economics of Investing in the Health of Livestock: New Insights? by Clem Tisdell, November 1996.
30. Macroeconomic Effects of Disease Control in the Thailand Livestock Sector – A CGE Analysis by T. Purcell, N. Karunaratne and C. Tisdell, January 1997.
31. The Thai Dairy Industry: Its Economic Evolution and Problems Raised by Land Rights and Cattle Diseases by T. Kehren and C. A. Tisdell, February 1997.
32. A Review of Economic Evaluations of Government Policies for the Control of Cattle Tick by R. Davis, February 1997.
33. Modelling to Predict Disease Incidence and Severity Using Age Specific Seroprevalence Data by G. Ramsay, March 1997.
34. Assessing the Effect of Vaccination on Disease Incidence and Severity by G. Ramsay, March 1997.
35. Calculating the Production Loss A Voided by Disease Control by G. Ramsay, March 1997.
36. Discounted Cash Flow Analysis of Diseases Control Programmes by G. Ramsay, C. A. Tisdell and S. R. Harrison, April 1997.
37. Private Decisions in Livestock Disease Control and the Value of Additional Information About Animal Health by G. Ramsay, S. R. Harrison and C. A. Tisdell, April 1997.
38. The Distribution of Benefits from Improved Animal Health Decision Making as a Result of the Collection of Additional Animal Health Information by G. Ramsay, C. A. Tisdell and S. R. Harrison, April 1997.
39. An Overview of the Occurrence of FMD in Thailand and Policies for its Control, by T. Kehren and C. A. Tisdell, September 1997.
40. Socio-Economic Status and Animal Disease Prevention and Treatment by P. Thani, T. Aphichatsarangkoon, B. Aekasing, L. Worachai, November 1997.
41. Production and Trade of Cattle, Buffalo and Pigs in Thailand by A. Smith and S. R. Harrison, December 1997.
42. Termination Report, Improved methods in diagnosis, epidemiology, economics and information management in Australia and Thailand by P. Black, December 1997.