



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

*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.*

RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS

AN ACIAR THAI-AUSTRALIAN PROJECT

Working Paper No. 5

**Livestock, the Environment and Sustainable
Development with Illustrations of Issues from
Thailand**

by

Clem Tisdell and Steve Harrison

June 1995



ISSN 1322-624X

RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS

Working Paper No. 5

**Livestock, the Environment and Sustainable Development
with Illustrations of Issues from Thailand¹**

by

Clem Tisdell² and Steve Harrison³

June 1995

© All rights reserved

¹ Paper prepared for the Third International Conference on Development and Future Studies, jointly organized by the International Institute for Development Studies and the Swedish School of Economics and Business Administration, Helsinki, Finland, July 31 - August 2 1995.

² School of Economics, The University of Queensland, St. Lucia Campus, Brisbane QLD 4072, Australia
Email: c.tisdell@economics.uq.edu.au

³ Agriculture and Food Sciences, The University of Queensland, St. Lucia Campus, Brisbane QLD 4072, Australia, Email: s.harrison@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) or Dr Steve Harrison, (s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

Livestock, the Environment and Sustainable Development with Illustrations of Issues from Thailand

ABSTRACT

There has been mounting environmental criticism of the livestock industry. Ruminants such as cattle have been implicated as significant contributors to greenhouse gases and it is argued that it is less food efficient to feed plant matter to livestock rather than have humans consume it directly. Furthermore, in many cases, livestock destroy natural vegetation and cause accelerated soil erosion as a result of overstocking often for socio-economic reasons. In other cases, such as in the Amazon rainforests have been cleared to provide pastures for cattle. Writers such as David Pearce and Charles Perrings have criticised socio-economic arrangements in Africa, e.g., in Botswana where the livestock industry involves common-property and forms of government assistance for grazing which are environmentally damaging. Furthermore, intensive livestock farming particularly in developed countries is a major source of pollutants. While some of these criticisms are justified, it is pointed out that there are counter considerations and that the livestock industry appears to have been discriminated against in some developing countries. The final portion of the paper reviews the development of the livestock industry in Thailand, the environmental issues raised by this development and the sustainability of the industry including aspects of animal health and diseases for its sustainability.

Keywords: livestock industry, intensive livestock farming, greenhouse gas, Thailand.

JEL Codes: Q1, Q54

Livestock, the Environment and Sustainable Development with Illustrations of Issues from Thailand

1. Background

Livestock numbers, especially cattle numbers have increased considerably throughout the world as human populations have risen, particularly the number of humans on higher incomes. The demand for meat and many other livestock products (such as dairy products) positively responds to increasing income levels particularly in the intermediate stage of transition of incomes from lower to higher levels (Hrabovszky et al., 1986). In addition, in some less developed countries (particularly in Africa), livestock continue to be an important source of draught power in agriculture. Increasing agricultural production to feed a rising population in such circumstances often requires an increase in livestock numbers to supply extra draught power (Nyamudeza, 1993). In the African case, this is still often provided by oxen. Furthermore with economic development, milk production tends to become a priority (as it now is in Thailand) because it is a good source of protein for children.

The increased demand for livestock has been accommodated in a number of ways. The grazing of livestock has been forced out of some land areas by extension of cropping and by urbanisation. This has been compensated for by the extension of grazing into new land areas e.g. by clearing of forest and woodland, and by intensification of land used for grazing e.g. by the use of fertilizers, and increased stocking rates. In addition, improvements in breeding and in veterinary products and practices have helped to increase livestock numbers. Furthermore, feed-lot, battery and factory-types of intensive production of livestock have expanded. Such livestock is fed by harvests from crops sometimes grown on marginal agricultural land.¹

These trends in livestock numbers and husbandry have not been without their critics. Opponents include animal liberationists, committed vegetarians against human slaughter of all animals, opponents on income distribution grounds, utilitarians who accord animals status in the utilitarian calculus and many conservationists and environmentalists who see increasing livestock populations as a threat to wildlife and to natural environments and as likely to undermine ecologically sustainable development.

It is useful to consider a number of these matters first of all from a moral perspective, then to examine, somewhat critically, views about the impact of livestock on wildlife and natural environments before turning to Thailand to provide a case study. The Thai case is interesting because it is a country that has recently gone from being a low income country to a medium income country.

2. A Moral Perspective on the Human Use of Livestock

Western economists have not as a rule afforded much standing to animals. Blackorby and Donaldson (1992) are a notable exception. Some utilitarians, including Blackorby and Donaldson, are prepared to accept that total utility depends not only on that of humans but also on that of non-human animals as well. According to Blackorby and Donaldson, even John Stuart Mill was prepared to countenance the extension of utilitarianism to cover all sentient creation. Blackorby and Donaldson (1992) writing in the *Economic Journal* suggest that the philosophy of Singer (1975, 1979, 1980) affords strong grounds for affording animals equal consideration of interests in terms of social policy.² Utilitarianism may take account of this in a number of ways. It may do this by means of ‘critical level’ utilitarianism, but average level or average level modified approaches (e.g. Ng, 1986) are also possible. The details need not concern us here. Blackorby and Donaldson (1992, p.1345) state “Animal exploitation in research or in food production has two important consequences: the fact that animals may suffer from pain, discomfort, illness and isolation and may live short lives; the second is that these activities cause large numbers of animals to be brought into existence”. They argue that the population of food animals would be much reduced if they were not consumed, and that some types may even become extinct.

Vegetarianism would in their view result in reduced populations of food animals. They claim that this will release resources. These resources in their view could be used for producing other commodities or could be made available to non-human animals. They continue “Because land is used to produce animal food, total land use in food production may fall and the land may be taken over by wild plants and animals. Alternatively, the resources may be used to increase the birth rate and therefore, the human population size” (Blackorby and Donaldson, 1992, p. 1357). However, if available food from animals for human consumption is reduced, this must be compensated for by increased food from other sources. This is likely to require the extension and possible intensification of cropping. Consequently, reduced

resource use may be much smaller than is suggested by those authors. Furthermore, cropping as compared to extensive grazing can in a number of circumstances lead to greater environmental damage.

Using a simple model, they argue that from a total utilitarian perspective, the competitive market solution to food supply can be expected to result in too high a consumption of meat from farm animals and excessive livestock numbers. Both the number of farm and research animals should be reduced on utilitarian grounds. Furthermore, in their view, “the consumption of dairy products is ethically preferable to meat consumption” (Blackorby and Donaldson, 1992, p. 1363) because dairy cattle typically have a longer life than farm animals bred for meat and length of life affects the utility obtained by animals.

They reinforce their argument for reduced population of farm animals on income distribution, conservation and environmental grounds. They state “malnutrition and starvation can be avoided by a switch to vegetarian diets, permitting food to be consumed directly by humans rather than first by animals (Lappé, 1971); the latter arrangement requires much more grain production. This argument has a good deal of moral force. A similar argument, that meat production increases the amount of land under cultivation and therefore, contributes to the decline of wild animals and to global warming, is similarly ignored” (Blackorby and Donaldson, 1992, pp. 1385-1386).

However, these matters are not so straightforward. As for the first matter, grain must be processed for human use and the energy requirements for this should be taken into account. More importantly, many animals such as cattle are able to digest plant matter which is indigestible or only poorly digestible by humankind. This means that some areas unsuitable for cropping such as some rangelands can be utilized for livestock production and so provide extra food for humans. Residues (from crops grown for humans) but unsuitable for human use can be fed to livestock. Use of livestock can increase the amount of food available for human consumption.³

As for the second matter, where cropping for direct human use of crops is an alternative to grazing, cropping is likely to be more destructive of natural vegetation cover and wildlife. Loss of natural vegetation cover contributes in a major way to the greenhouse effect.⁴ Furthermore, soil disturbance for cropping is liable to result in a faster rate of loss of organic matter from the soil than grazing and so add to increases in carbon dioxide levels. In addition,

soil erosion tends to be more severe from cropping than for grazing.

Blackorby and Donaldson also claim that livestock utilisation for meat has adverse income distributional consequences. For example, poorer members of the world community usually have a low-meat diet. Competition for land for livestock may force up vegetable prices adversely affecting this group. While this is so, some of the poorer members of the world community are also suppliers of meat products and may gain from demand for meat.

The situation is more complex than seems to be the case at first sight. Let us therefore investigate the relationship between livestock and the conservation of wildlife and natural resources in more detail.

3. Livestock and the Conservation of Wildlife and Natural Resources

The world's livestock industries are increasingly the target of environmental criticism (e.g., Durning and Brough, 1991) of which that emanating from the World Resources Institute, UNEP and UNDP is representative. A recent publication of WRI, UNEP and UNDP states:

“The world's livestock population is growing much faster than its human population, diverting resources that could be used to grow grains for human consumption. A wide range of environmental problems are associated with raising livestock and with leather processing. Overgrazing contributes to soil degradation and devegetation; in arid lands, overgrazing can lead to desertification” (World Resources Institute, UNEP, UNDP, 1994, p. 12).

The document goes on to point out that expansion of the livestock industry has hastened conversion of forest to pasture, and that feedlots in industrialized countries create manure disposal and water pollution problems. The process of tanning hides is the source of considerable water pollution in developing countries. These are significant environmental problems but they also need to be critically analysed.

The impact of livestock on conservation of wildlife and natural resources cannot be reasonably assessed without considering alternative forms of land use. As a form of land-use, grazing usually has a smaller adverse impact on wildlife than cropping. On the other hand, livestock can utilize areas completely unsuitable for cropping. Consequently, it is able to extend the area of human disturbance of natural environments.

Environmentally the case for using land areas for cropping rather than grazing is not strong, unless additional cropping would reduce the total area of the natural environment disturbed by humankind. Unfortunately, the actual global pattern of economic 'development' has been to extend the land area disturbed by mankind and to do so more intensively with the passage of time (Cf. Tisdell, 1994a). The proportion of the world's land used for cropping and grazing has increased at the expense of forest and woodland and this process continues (see for example, World Resources Institute, UNEP and UNDP, 1994, p. 283). It has increased for example in Australia, Brazil, Indonesia and Thailand. Forests and woodland have been cleared in all of these countries to extend agriculture and grazing. This is part of a global pattern resulting from increasing human populations and desires for rising per capita income levels. Here are the sources of our global environmental problems. However, it is far from clear that a switch to vegetarianism will solve those problems.

The relationship between soil erosion and degradation and grazing is complex. In parts of Africa (e.g. the Ukambani region of Kenya) the feeding of crop residues to cattle is reducing the humus level of soils and leading to reduced sustainability of crop yields (Tisdell, 1994b).⁵ However, the basic problem is rising densities of human population and failure to return cow manure from the bomahs (yards holding cattle at night) to the cropped land.

In most cases, extensive grazing results in less soil erosion and degradation than cropping. The following comparative rates of soil loss have been suggested for alternative use of sloping lands in coastal Queensland:

"Six major agricultural land use systems can be identified in the steeplands of coastal Queensland. They are:

- | | | |
|----------------------------------|---|---|
| a) Annual Crops | - | vegetables, sugar cane |
| b) Permanent Crops (non mulched) | - | papaws, bananas, pineapples |
| c) Permanent Crops (mulched) | - | avocados, macadamia nuts |
| d) Grazing | - | beef, dairying |
| e) Forestry | - | native hardwood, plantation
softwood |
| f) Rural Residential | - | low to medium density
housing. |

The levels of degradation in these land use systems increase with the frequency and intensity of cultivation. The three cropping systems (a – c), have the highest levels of degradation with annual or frequently cultivated crops most at risk. Soil losses of between 85 and 300 t/ha/yr

have been measured in newly planted pineapples and sugar cane, the higher soil losses occurring in the wetter northern tropics (Capelin 1987 and Freebairn 1982).” (Dwyer and Deuter, 1993).

A number of African studies suggest that as far as communal grazing is concerned a reduction in livestock densities would have little or no perceptible influence on the rate of soil erosion in many parts of sub-Saharan Africa (Abel, 1992). Furthermore, if ‘overstocking’ occurs, it is sustainable in many instances because the rate of soil erosion is such that livestock yields can be maintained at current levels for the next 300-400 years. (Biot, 1992; Scoones, 1992b). Nevertheless, some writers argue that communal grazing and nomadism result in less satisfactory environmental and economic consequences than grazing on private commercial properties.

Referring to well-known consequences of open-access, this group of natural resource economists sees communal grazing and nomadism as resulting in overstocking and underinvestment in improvements of rangeland for livestock. They see such institutional factors as the prime cause of sustainability problems arising from land use. However, care is needed in generalising (see Long, 1994) about this matter because according to Scoones (1992a, p.339), for instance, “returns to land in communal area livestock are considerably higher than in commercial beef ranching systems [in Southern Zimbabwe], as long as the full value of livestock production and services are accounted for”. The returns from communal animal livestock come from their subsistence use and their inputs to other activities, e.g. their use for draught power. On the other hand, in contrast to commercial livestock production, no surplus is available for urban use or export. Nevertheless; commercial livestock production is not an economic use of land in Scoones’ view and also in his view there is little or no evidence of declines in the productivity of communal land due to overstocking in the area of Zimbabwe studied by him, (Scoones, 1992, ed. 356).

A number of government policies in parts of Africa and elsewhere to support grazing development have had unfortunate environmental consequences. These have included subsidies for the removal of trees and provision of extra watering points for cattle (Pearce et al., 1988). Nevertheless, as shown by Perrings (1993), it does not follow that complete reliance on market forces would improve the sustainability of the sub-Saharan livestock industry.

While the livestock industry may be favoured in some African countries, as in Botswana, this is by no means the general rule throughout Africa (or the rest of the world) where extension of cropping seems to have precedence. This has led to considerable conflict between pastoralists and farmers in developing countries (Bennett, 1991). Expansion of farming is depriving nomadic livestock herds of water supplies, of routes for their movement and of food supplies. Such developments can reduce rather than increase the overall food supplies in a country e.g. without access to water pastoralists may be unable to utilize rangeland previously utilized for grazing thereby causing a fall in livestock production which may not be compensated for by increased agricultural production⁶. In cases such as this, an integrated approach to land use is desirable (Cf. Brink et al., 1995).

Many of the criticisms made by Blackorby and Donaldson (1992) of the livestock industry may be particularly applicable to this industry in high income countries. Intensive livestock production based on the use of grains is more common in such countries and the waste products from such production can be a significant source of water pollution and offensive smells, both of which require environmental controls. Countries undergoing transition from low income to higher income levels such as Thailand can expect their livestock industry to develop in this direction.

4. Possible Environmental Implications of Development of the Thai Livestock Industry

Thailand has experienced considerable increases in income levels and in population in recent decades. It has therefore experienced considerable increase in demand for meat and milk. Hrabovszky et al., (1986, p.103) indicate that population growth and increasing income levels are the two most important contributors to rising demand for meat and milk, which globally has been rising at 4% per year with 2.5% of the rate of growth being attributed to population increase and 1.5% to income increases. For developing countries, the income elasticity of demand for livestock products appears to be around 0.6 (Hrabovszky et al., 1986, pp. 3). Predictably, this general observation applies to Thailand which has experienced rapid economic growth.

Thailand has expanded its production of pork and poultry products considerably and while cattle numbers have increased, they have not risen to the same extent. As a result, Thailand is a large net importer of beef and milk products.

Livestock production is becoming increasingly commercialized in large intensive operations as opposed to village production. This trend is likely to continue as improved transport and communications systems in Thailand turn the whole economy increasingly into a market economy.

The expansion of agriculture and grazing in Thailand (as well as timber harvesting) resulted in major deforestation throughout the country but little scope now remains for continuing deforestation because Thailand seems determined to save its remaining forested areas. However, this is no guarantee that Thailand's pattern of deforestation will not be repeated in nearby countries such as Laos as they expand agricultural and livestock production, partially to provide exports to countries such as Thailand.

As expected, demand for draught animals in Thailand has declined with its economic development. Buffalos are being replaced in the fields by small tractors with spiked iron wheels and increasingly motor vehicles are replacing oxen for transport purposes. Nevertheless, the decline in this demand is more than counteracted by the rising demand for cattle for beef, and the demand for buffalo for meat remains high, especially in the north-west of Thailand. Thailand is a major net importer of beef and has become a significant net exporter of pork and of poultry meat with exports to Asian markets and to Europe. Its exported pig and poultry products are mostly produced in intensive large scale factory-type operations increasingly converging to the pattern in more developed countries.

As a part of Thailand's process of increasing livestock production, local breeds are being increasingly replaced by imported improved breeds of livestock. These breeds have high yields under controlled environmental conditions but are not as hardy as native breeds (Khan, 1993, p.3). Some may, for example, be more susceptible to local diseases such as foot-and-mouth disease. Consequently, the husbandry of these animals needs to be more intensive and their environments must be carefully controlled (Khan, 1993, p.3). For example, special precautions must be taken to counteract animal diseases, if production is to be sustained, for example, vaccination against diseases where possible, special precautions to reduce the spread of infections or eradicate diseases where possible. Thus there is increasing concern in Thailand about animal diseases, a concern reinforced by Thailand's desire to expand its export markets for pig and poultry products.

The loss of local livestock breeds in Thailand will reduce biodiversity and add to long-term

problems of maintaining livestock productivity as specialized breeds became vulnerable to changing or evolving diseases. This sustainability issue has become a problem for all modern farming systems.

The future growth of the livestock industry in Thailand is likely to be towards increasing commercialisation and large-scale intensive production. The type of environmental problems encountered in more developed countries in livestock production can be expected to become more common in Thailand. Furthermore, the relative (and most likely absolute) contribution of village livestock production to total livestock production can be expected to decline. This trend is already apparent for pig production and will obviously have income distribution consequences: village income from livestock may decline because of competition from commercial factory-type production of livestock.

5. Concluding Comments

Livestock and agricultural production has expanded and intensified throughout the world to meet the demands of a rising global population and a growing group of humans with rising incomes. This has placed natural environments under increasing pressure and has been a major factor in the reduction of the use of woodland and forest. Wildlife and biodiversity have suffered and the extent of carbon sinks appears to have been reduced. Furthermore, native varieties of livestock are being increasingly replaced by improved varieties reducing the biological diversity of livestock and making evolving populations highly susceptible to adverse environmental changes (Khan, 1993). Nevertheless, as pointed out, some of the claims about the adverse effects of livestock on the availability of food for human consumption and natural environments are misleading. In this respect, it needs to be borne in mind that cropping is likely to have a greater adverse impact on natural environments than grazing. Thailand was used to illustrate types of changes which occur in the livestock industry as economic growth occurs. If anything, this study indicates the importance of controlling the growth of human populations in order to achieve sustainable development. This is because ultimately the expanding environmental degradation attributed to the livestock industry has its genesis in increasing human populations and rising incomes, the sources of rising demand for livestock.

6. Acknowledgments

Research for this article was partially funded by Australian Centre for International Agricultural Research Project No. 9204, "Animal Health in Thailand and Australia: Improved Methods in Diagnosis, Epidemiology, Economics and Information Management". The views expressed here are not necessarily those of ACIAR or of collaborating research bodies. We wish to thank Tom Murphy for research assistance and Rodney Beard for his useful comments.

7. Notes

1. Note that these broad classes of livestock production can be identified and these can have differing environmental impacts. These are:
 - a) extensive or rangeland livestock where crops are not grown;
 - b) a combination of mixed cropping and livestock and
 - c) intensive rearing of livestock.

In practice, there is virtually a continuum between systems e.g. some extensive systems involve improved pastures the management of which can verge on cropping.

2. The possibility has also been considered that the application of the Rawlsian principle of social justice (Rawls, 1971) should be extended to include animals (Tisdell, 1993, Ch. 8).
3. There are also other matters to consider. Protein obtained from animals seems to play an important role in human diets and human health. Furthermore there can be important complementarities in production between livestock and production (e.g. feeding of crop residues to livestock, feeding of crops which have failed due to drought and use of dung for vegetable production - as revealed by our village surveys in Thailand). Devendra (1993) states that there is significant complementarity between crops and livestock which allows nutrient recycling, energy savings and additions to value in production in South-East Asia.
4. In addition, it has been claimed ruminants are significant emitters of greenhouse gases,

notably methane and carbon dioxide, being responsible for up to 20 per cent of methane emissions (Khan, 1993). Further details may be found in Leng (1993).

5. A similar problem was observed by Dr S. Harrison on fieldwork in Inner Mongolia while inspecting an irrigation project there. Stubble from the irrigated crop was to be fed to livestock but the soil was sandy and subject to salinization. Therefore, return of stubble for provision of humus was important for sustaining the productivity of the soil. Although it was planned to return dung to the cropland, this was estimated to provide only a fraction of the organic matter budget needed for sustainable cropping.
6. However, a possibility also exists in certain cases of using cropping for supplementary feeding for livestock. In this mixed production system, grazing pressures may actually increase because livestock densities rise on remaining rangeland, a possibility noted for example by Longworth and Williams (1993).
7. This neo-Malthusian view is shared by many economists, e.g., see Daly (1980), Tisdell (1991), Daily and Ehrlich (1992) and recent issues of *Ecological Economics*.

8. References

- Abel, N.O.J. (1992) 'Reducing Cattle Numbers on Southern African Communal Range: Is It Worth It?' Pp. 173-195 in R.H. Behnke, I. Scoones, and C. Kerven, *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaption in African Savannas*, Overseas Development Institute, London.
- Bennett, O. (1991) *Greenwar: Environment and Conflict*, Panos, London.
- Biot, Y. (1992) 'How Long Can High Stocking Densities be Sustained?' Pp. 153-172 in R.H. Behnke, I. Scoones, and C. Kerven, *Range Ecology at Disequilibrium: New Models of Natural Variability and Pastoral Adaption in African Savannas*, Overseas Development Institute, London.
- Blackorby, C. and Donaldson, D. (1992) 'Pigs and Guinea Pigs: A Note on the Ethics of Animal Exploitation', *The Economic Journal*, **102**: 1345-1369.

- Brink, R. van den; Bromley, D.W. and Chavas, J-P. (1995) 'The Economics of Cain and Abel: Agro-Pastoral Property Rights in the Sahel', *Development Studies*, **31**:379-399.
- Capelin, M. (1987) 'Horticultural Land Suitability Study, Sunshine Coast- S.E. Queensland', **Land Resource Bulletin** QV 87001, Queensland Department of Primary Industries, Brisbane.
- Daily, G.C. and Ehrlich, P.R. 'Population Sustainability, and Earth's Carrying Capacity', **BioScience**, **42**(10): 761-771.
- Daly, H. (1980) *Economics, Ecology and Ethics*, Freeman, San Francisco.
- Devendra, C. (1993) 'Sustainable Animal Production for Small Farms in South-East Asia' FAO.
- Durning, A.T. and Brough, H.B. (1991) *Taking Stock: Animal Farming and the Environment*, Worldwatch Paper No. 103, Worldwatch Institute, Washington.
- Dwyer, G. and Denter, P. (1993) 'Towards an Evaluation of Sustainability of Steeplands in Coastal Queensland'. Paper delivered at IBSRAM/ACIAR/FESLM workshop, October 11-13, 1993, Brisbane.
- Freebairn, D.M. (1982) 'Soil Erosion in Perspective', *Technical News*, **6**:12-15, Division of Land Utilization, Queensland Department of Primary Industries, Brisbane.
- Hrabovszky, J., Gartner, J. and Riveros, F. (1986) 'Changes in the Role of Rangelands in the Land Use Systems of Developing Countries'. Pp. 10 -110 in P.J. Joss, P.W. Lynch, and O.B. Williams (eds), *Rangelands: A Resource Under Siege*, Cambridge University Press, London.
- IUCN (1980) *World Conservation Strategy*, IUCN, Gland, Switzerland.
- Khan, A.Z.M. (1993) 'Livestock and Sustainable Agricultural Development' *Asian Livestock*, **18**(1), 1-4.
- Lappé, F.M. (1971) *Diet for a Small Planet*, Ballantine, New York.
- Leng, R.A. (1993) 'The Impact of Livestock on Environmental Change'. Pp. 59-75 in S. Mack (ed) *Strategies for Sustainable Animal Agriculture in Developing Countries*,

- FAO, Rome.
- Long, N.V. (1994) 'On Optimal Enclosure and Timing of Enclosure', *The Economic Record*, **70**, 368-372.
- Longworth, J.W. and Williams, G.J. (1993) *China's Pastoral Region: Sheep and Wool, Minority Nationalities, Rangeland Degradation and Sustainable Development*, CAB International, Wallingford, UK.
- Ng, Y.K. (1986) 'Social Criteria for Evaluating Population Change: An Alternative to the Blackorby-Donaldson Criteria' *Journal of Public Economics*, **29**, 375-381.
- Nyamudeza P. (1993) 'Evaluation of Sustainability of Vertisols in Zimbabwe', Save Valley Experiment Station, Postal.Bag 2037, Chipinge, Zimbabwe, mimeo. Paper delivered at ffiSRAM/ACIAR/FESLM Workshop, October 11-13, 1993, Brisbane.
- Perrings, C. (1993) 'Stress, Shock, and the Sustainability of Optimal Resource Utilization in a Stochastic Environment'. Pp. 66-95 in E.B. Barbier, (ed.) *Economics and Ecology: New Frontiers and Sustainable Development*, Chapman and Hall, London.
- Rawls, J.R. (1971) *A Theory of Justice*, Harvard University Press, Cambridge, Mass.
- Scoones, I. (1992a) 'The Economic Value of Livestock in the Communal Areas of Southern Zimbabwe', *Agricultural Systems*, **38**: 339-359.
- Scoones, I. (1992b) 'Land Degradation and Livestock Production in Zimbabwe's Communal Areas', *Land Degradation and Rehabilitation*, **3**: 99-113.
- Singer, P. (1975) *Animal Liberation: A New Ethics for Our Treatment of Animals*, Avon, New York.
- Singer, P. (1979) *Practical Ethics*, Cambridge University Press, Cambridge.
- Singer, P. (1980) 'Animals and the Value of Life'. In T Regan (ed) *Matters of Life and Death: New Introductory Essays in Moral Philosophy*, Random House, New York.
- Tisdell, C.A. (1991) *Economics of Environmental Conservation*, Elsevier Science, Amsterdam.

Tisdell, C.A. (1993) *Environmental Economics*, Edward Elgar, Aldershot, England.

Tisdell, C. (1994a) 'Conservation, Protected Areas and the Global Economic System: How Debt, Trade, Exchange Rates, Inflation and Macroeconomic Policy Affect Biological Diversity', *Biodiversity and Conservation*, **3**: 410-436.

Tisdell, C. (1994b) 'Population, Economics, Development, and Environmental Security.' Pp. 63-84 in N. Polunin and M. Nazim (eds) *Population and Global Security*, The Foundation for Environmental Conservation, Geneva.

World Resources Institute, UNEP and UNDP (1994) *World Resources 1994-95*, Oxford University Press, Oxford.

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.