Management of internal parasites in goats in the Philippines

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Management of internal parasites in goats in the Philippines

N.D. Montes, N.R. Zapata Jr, A.M.P. Alo and J.D. Mullen

2008

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Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Department of Science and Technology (DOST)

The Australian Centre for International Agricultural Research (ACIAR) operates as part of Australia's international development cooperation program, with a mission to achieve more productive and sustainable agricultural systems, for the benefit of developing countries and Australia. It commissions collaborative research between Australian and developing country researchers in areas where Australia has special research competence. It also administers Australia's contribution to the International Agricultural Research Centres.

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Foreword

The Australian Centre for International Agricultural Research (ACIAR) has long had in place a comprehensive impact assessment program. The Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) has also undertaken impact assessment studies for an extensive period and has recently substantially expanded its assessment program.

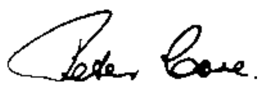
ACIAR and PCARRD have been partners in collaborative research and development (R&D) activities since ACIAR's inception. The two organisations feel that there are mutual gains from expanding this collaboration to the impact assessment activities each of them undertakes. The Bureau of Agricultural Research of the Philippine Department of Agriculture is also developing an impact assessment program. All three organisations have agreed to develop collaborative impact assessment activities, and share resources and experience to make these studies more effective.

In 2007–08, three assessment studies were commissioned. This report, which assesses the impact of research on the management of parasites in goats in the Philippines, gives the results of the first of these studies and was developed primarily by PCARRD and ACIAR. The results of the other studies will appear in ACIAR's Impact Assessment Series as they are finalised.

The R&D assessed in this study developed a package of best practice and technologies, and researchers worked with other domestic and international development organisations to devise a unique approach to transferring the package to smallholders. The outcome has been a significant uptake of the technologies, especially in the focus regions of the Philippines. There has been a significant increase in goat production by smallholders due to the substantial reduction in goat morbidity and mortality.

The study shows that the returns on the R&D investment by all organisations—not just ACIAR and PCARRD—are, in net present value terms, PHP2,530 million or A$66 million. The investment has generated a benefit:cost ratio of 10.4:1 and an internal rate of return of around 25%.

ACIAR and PCARRD are pleased that this collaborative assessment study has worked well and congratulate the study groups from both countries on this successful outcome.



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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AT	agricultural technician
BAI	Bureau of Animal Industry (DA)
BAS	Bureau of Agricultural Statistics
CASREN	Crop–Animal Systems Research Network
CAO	city agricultural office
CAT	city agricultural technician
CLSU	Central Luzon State University
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DA	Department of Agriculture (Philippines)
DA–BAR	Bureau of Agricultural Research of the Department of Agriculture
DA–RFU	Department of Agriculture regional field unit
DMMSU	Don Mariano Marcos Memorial State University
DOLE	Department of Labor and Employment (Philippines)
DOST	Department of Science and Technology (Philippines)
FAO	Food and Agriculture Organization of the United Nations
FLS	Farmers' Livestock School
FSP	Forages for Smallholders Project
GLORIA	general livestock opportunities, risks and innovation analysis [computing software]
IDRC	International Development Research Centre (Canada)
IFAD	International Fund for Agricultural Development
IGM	Integrated Goat Management
ILIARC	Ilocos Integrated Agricultural Research Center
ILRI	International Livestock Research Institute
IRR	internal rate of return
LGU	local government unit
MAO	municipal agricultural officer
MVO	municipal veterinary office
NGO	non-government organisation
NPV	net present value
PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
PHP	Philippine peso
PVO	provincial veterinary office
R&D	research and development
RED	Rural Enterprise Development (project)
SPC	sustainable endoparasite control
TAG	Technical Assistance Grant
TESDA	Technical Education and Skills Development Authority

Acknowledgments

We have surely benefited from the collaboration of many people during the evolution of this paper. Thus, we are profoundly grateful to the University of the Philippines at Los Baños through its Office of the Vice-Chancellor for Research and Extension; the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development through its Socio-Economic and Livestock divisions; and ACIAR and the Bureau of Agricultural Research of the Department of Agriculture for their financial support and excellent technical assistance. Special thanks go to Dr Edwin C. Villar and Ms Anna Marie Alo of the Livestock Division of PCARRD, Dr Felix Valenzuela of the Department of Agriculture–Livestock Division, Dr Jeff Davis of ACIAR and Dr G. Douglas Gray of the International Livestock Research Institute – International Fund for Agricultural Development (now with ACIAR), who have generously contributed their insightful comments and helpful suggestions.

In addition, we have greatly appreciated the tireless cooperation of the Department of Agriculture–Livestock Division, DA–RFU 1 and 7, the pertinent provincial government and local government units, and the municipal agricultural officers and agricultural technicians. We thank particularly the SPC-TAG 443, FLS–IGM and CASREN farmer-participants—the 'spillover' and 'control' farmers who made major contributions by giving their valuable time and effort in appropriately responding to questions during the impact assessment survey, and made concrete suggestions for changes and improvements. They stressed to us the importance of the goat enterprises and allied industries as an alternative means of livelihood in their communities and the substantial benefits derived from sustainable endoparasite control in small ruminants.

We also extend our gratitude to Dr Liborio Cabanilla, Dean of the College of Economics and Management, who established important linkages and networking with key research institutions, and provided strategic leadership and motivation for the faculty to actively engage in this assessment. The Department of Agribusiness Management also provided strong administrative support during the conduct of the assessment.

Finally, we acknowledge the many people who are not mentioned here but whose continuing support and assistance is nevertheless worthy of recognition.

Summary

The assessment of the impact of research and development (R&D) into the management of parasites in goats in the Philippines reported here is one of three such impact assessments commissioned collaboratively by the Australian Centre for International Agricultural Research (ACIAR), the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the Bureau of Agricultural Research of the Department of Agriculture (DA–BAR).

ACIAR has had a strong culture of assessing the impact of its research investments. Peak agricultural research institutions in the Philippines, including PCARRD and DA–BAR, have been interested in applying ACIAR's experience to further develop their own capacity in impact assessment. In 2007 ACIAR, PCARRD and DA–BAR decided to jointly fund impact assessments of three areas of R&D supported by ACIAR in the past.

Here we report an assessment of the impact of research funded by ACIAR, the International Fund for Agricultural Development (IFAD), the International Livestock Research Institute (ILRI), PCARRD, the Department of Agriculture (DA) in the Philippines and local government agencies into management strategies that reduced morbidity and mortality in goats, particularly goat kids, in the Philippines. The development of a goat industry has been seen as an important way of improving the welfare of poor families. However, endoparasites limit production, and resistance to anthelmintics makes management more difficult.

With assistance from ILRI and PCARRD, ACIAR funded a project researching endoparasite control in goats (ACIAR project AS1/1997/133, *Sustainable endoparasite control for small ruminants in South-East Asia*). Other projects were and still are funded by IFAD, ILRI, PCARRD and local government, and these are further detailed in this paper.

Because of the potential of the technology to improve the livelihood of smallholders, national agricultural institutions and local government have continued to fund extension programs on parasite control in goats. The total investment in these projects in 2007 values is A$5.8m or Philippine pesos (PHP) 225m.

The ultimate objective of the impact assessment reported here was to estimate the rate of return from the investment in the Philippines on research leading to increased production from goats on smallholder farms as a result of better control of internal parasites. This required an assessment of the on-farm efficiency gains, and of the rate and extent of adoption of the technologies by smallholder goat producers.

Application of the technology results in a large reduction in mortality in kids, from about 70% to less than 5%, thus allowing the sale of many more surplus goats. We estimated that, even after allowing for extra housing, labour and forage costs, the unit cost of producing goat meat fell by almost PHP10 per kg live weight in 2007.

Extension of the technology focused on Regions 1 and 7 where annual production has been steady at around 20,000 tonnes in recent years. Under this scenario, the annual potential welfare gain to the Philippines from adoption of the parasite control technologies by all goat producers in Regions 1 and 7 is PHP194m or $A5m in 2007 values, with 83% of these benefits accruing to goat producers.

A key means of promoting adoption has been a series of farmer livestock schools run through a number of programs funded by PCARRD and local authorities. Based on attendance at these schools and on a survey conducted during the course of the impact assessment, we estimate that, from 2001, the rate of adoption has grown to almost 30% amongst goat producers in Regions 1 and 7.

We expect adoption to continue to grow in Regions 1 and 7. In part this arises as the technology spills over from adopters to their neighbours. However, a more important source of increased adoption is the continuing investment by PCARRD, DA and local government units (LGUs) on extension activities. Based on existing extension programs and the high priority given to the development of the goat industry by PCARRD, DA and LGUs, we expect that expenditure on parasite management technologies in the goat industry in Regions 1 and 7 will continue at the rate of PHP3.5m per year to 2030. In this scenario, based on the observed rate of adoption in recent years, we expect the adoption rate to reach 75% by 2015 and remain there until 2030.

At this rate of adoption, and projecting these benefits to 2030, the present value of benefits to the Philippines amounts to PHP2,800m or $A73m. After deducting the investments made by ACIAR, PCARRD and other partners, the net present value (NPV) of the investment was PHP2,530m or A$66m. The benefit:cost ratio was 10.4:1 and the internal rate of return (IRR) was almost 25%. Table 1 summarises these returns on investment.

The investment by ACIAR was A$0.5m, which amounted to 7.3% of the total investment in this program of R&D. Attributing benefits to ACIAR at this rate gives a NPV to the ACIAR investment of A$4.8m.

This has been a profitable investment by ACIAR and its Philippine and international partners, contributing to poverty alleviation among livestock smallholders in the Philippines.

The analysis has been conducted under a conservative set of judgments. We have confined it to increased adoption in Regions 1 and 7 but there may be profitable opportunities to extend the technology to other regions in the Philippines. Recall also that those goat farmers who do not adopt the technology will lose if its adoption causes the price of goats to fall.

Even holding investment and adoption at 2007 levels—an ex-post scenario—gives a strong level of financial return, with the benefit:cost ratio being 5.6:1, the NPV PHP1,025m (A$27m) and the IRR 19%. The NPV to ACIAR under this scenario is A$2.3m.

A third scenario we chose to examine was where the cost reduction was larger than our budgeted estimates given above. If the cost reduction (*k*-shift) were 10% higher at 10.3%, total annual potential welfare gains would increase to PHP214m (A$5.6m). Under the baseline scenario, where the level of adoption increased to 75%, the benefit:cost ratio would increase to 11.5, the IRR to 26% and the NPV to PHP2,825m (A$73 m). Were the adoption rate to remain at 30%—the ex-post scenario—the benefit:cost ratio would be 6.1:1, the IRR 20% and the NPV PHP1,156m ($A30m).

The delivery of this information-based technology for managing parasites through intensive training schools and participatory research on farms was seen as not only important to achieving its adoption by goat farmers but also to building human capacity among farmers and research and extension workers. The farmer-adopters have increased capacity to apply principles learnt to their other farm enterprises. There is a greater capacity within PCARRD, the DA and local government to deliver complex technologies through this participatory research and training approach. These capacity-building benefits were not estimated in this assessment because it is still too early to identify just how they will translate into impacts. Based on other recent impact assessments that ACIAR has commissioned, this improved capacity could add returns at least similar to those derived directly from the R&D.

Table 1. Summary of benefits and costs of ACIAR project AS1/1997/133

Item	Units	To total project funding	To ACIAR funding
Total costs	A$m (PHPm)	6.99 (270.2)	0.5
Total benefits	A$m (PHPm)	72.54 (2,803.0)	5.3
Net benefits	A$m (PHPm)	65.55 (2,532.8)	4.8
Benefit:cost ratio	Ratio	10.4:1	10.4:1
Internal rate of return	%	24.7	24.7

1 Background and objectives of the impact assessment study

The Australian Centre for International Agricultural Research (ACIAR) has had a strong culture of evaluating the impact of its research investments to demonstrate their value to taxpayers in Australia and partner countries, and to guide the allocation of research resources in the future to potentially higher pay-off ends.

Peak agricultural research institutions in the Philippines, including the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) and the Department of Agriculture–Bureau of Agricultural Research (DA–BAR), have been interested in applying ACIAR's experience to further develop their own capacity in impact assessment. In 2007, ACIAR, PCARRD and DA–BAR decided to jointly fund impact assessments of three areas of research and development (R&D) supported by ACIAR and Philippine and other partner institutions. The partners agreed to conduct impact assessments in the following three areas:

- the control of endoparasites in goats
- the development of two-stage drying processes for grains, including rice
- pest management in grain storage in the face of developing pesticide-resistance problems.

A number of criteria guided the choice of research areas to be assessed. The research had to have been largely completed, so that the industry had had time to adopt the technologies. In this first round of impact assessments, there was a deliberate attempt to select research areas where at least the science was thought to have been successful, even if the level of adoption was uncertain. An attempt was made to assess various types of technology in different industries at different points in the marketing chain. The interests, priorities and skills of the three partners influenced the choice. In each case, the program of research assessed consisted of a number of sequential research projects funded by ACIAR, and sometimes projects funded by other agencies such as the International Fund for Agricultural Development (IFAD) and PCARRD that were inextricably linked to the ACIAR projects.

ACIAR commissioned Dr John Mullen from the Department of Primary Industries, New South Wales, Australia, to coordinate the assessments with Philippine collaborators. PCARRD and DA–BAR commissioned economists and experts from the University of the Philippines at Los Baños, the Bureau of Agricultural Statistics (BAS) and the Philippine Rice Research Institute to work with Dr Mullen. These organisations also provided in-kind support to the impact assessment process.

Here we report an assessment of the impact of research funded by ACIAR, IFAD, the International Livestock Research Institute (ILRI), PCARDD, DA–BAR and local government agencies into management strategies that reduced morbidity and mortality in goats, particularly goat kids, in the Philippines.

Goats are an important component of smallholder farming systems in the Philippines and other countries in South-East Asia. The development of a goat industry has been seen as an important way of improving the welfare of poor families in this region, partly because the capital investment and associated risks in raising goats are lower than for larger ruminants. However, endoparasites limit production, and resistance to anthelmintic drugs makes the management of internal parasites more difficult (Hood 2004).

During the wet season, goats, particularly the growing kids, succumb to diarrhoea and pneumonia. In the Philippines, backyard goat farmers point to a 60–80% mortality rate from the onset of the wet season until the peak rainy months (ILRI–IFAD–PCARRD 2003). Costs associated with goat mortality and meat loss are high (Gray et al. 1999). Annual economic losses associated with roundworm parasitism in the Philippines have been estimated at US$3.55m.

Chemical deworming is simple and cost-effective, and promotes rapid and sustained growth in goats, but this technology has never been widely adopted, perhaps partly because of the cash outlays involved. Moreover, the emergence of parasite resistance to several of the active chemical groups in drugs is increasingly constraining their use.

In response to these problems, ACIAR supported a workshop on 'Sustainable parasite control' in Bogor, Indonesia, in April 1996. The workshop concluded that:

> Small ruminants, especially goats, are of high priority in farming systems in most countries in South and Southeast Asia, particularly for smallholders and the landless poor. Endoparasites were identified as a major constraint to their productivity.

With assistance from ILRI and PCARRD, ACIAR funded a project researching endoparasite control in goats. Other projects, some of them still in progress, were funded by IFAD, ILRI and PCARRD. They are further detailed in this paper.

The projects were expected to contribute to poverty alleviation of smallholder farmers through the increased productivity that would result from the integrated control of endoparasites in goats based on improvements in housing, grazing and disease management, feed and nutrition, and sanitation, as well as strategic deworming and selective breeding. The focus was on means of reducing worm load by other than chemical dewormers. The project was also expected to lead to positive environmental benefits through reduced use of drugs and chemicals, although it seems that few smallholders were using chemical control measures at the time.

The ultimate objective of the impact assessment reported here was to estimate the rate of return to ACIAR's investment in the Philippines on research leading to increased production from goats on smallholder farms, as a result of better control of internal parasites. This required an assessment of the on-farm efficiency gains, and of the rate and extent of adoption of the technologies by smallholder goat producers. Estimates of changes in welfare were related to the R&D investment made to generate them, to indicate if the work has been a good use of ACIAR's finite research resources. We employed the approach to impact assessment detailed in the guidelines recently completed by ACIAR (Gordon and Davis 2007). Figure 1 summarises our approach in undertaking the assessment.

Major steps in the impact assessment included:

- describing the background to the ACIAR projects, the research processes undertaken and the links with other projects and agencies conducting research in this area
- describing and analysing the impact or adoption pathway by identifying project results and causal links, and mapping inputs to project benefits
- relating inputs, outputs and outcomes from the project within a benefit–cost framework.

Key parameters used in the impact assessment were based on BAS data, research results, the judgments of research and extension personnel, and the findings of a survey conducted as part of the impact assessment. The survey was conducted during March–May 2008 in selected provinces and municipalities within Regions 1 and 7, where the highest numbers of goats are raised and where the technologies developed from the ACIAR project have been further developed and promoted by subsequent technology dissemination projects (e.g. SPC-TAG 443, CASREN and FLS-IGM).

A number of factors confound the analysis. First, as noted above, ACIAR has not been the only agency supporting research into the management of parasites in goats. It is difficult to attribute, between the various agencies that made investments, the welfare gains from the body of research and extension undertaken. Our general approach has been to avoid making attributions. Rather, we have assessed the returns to total investment

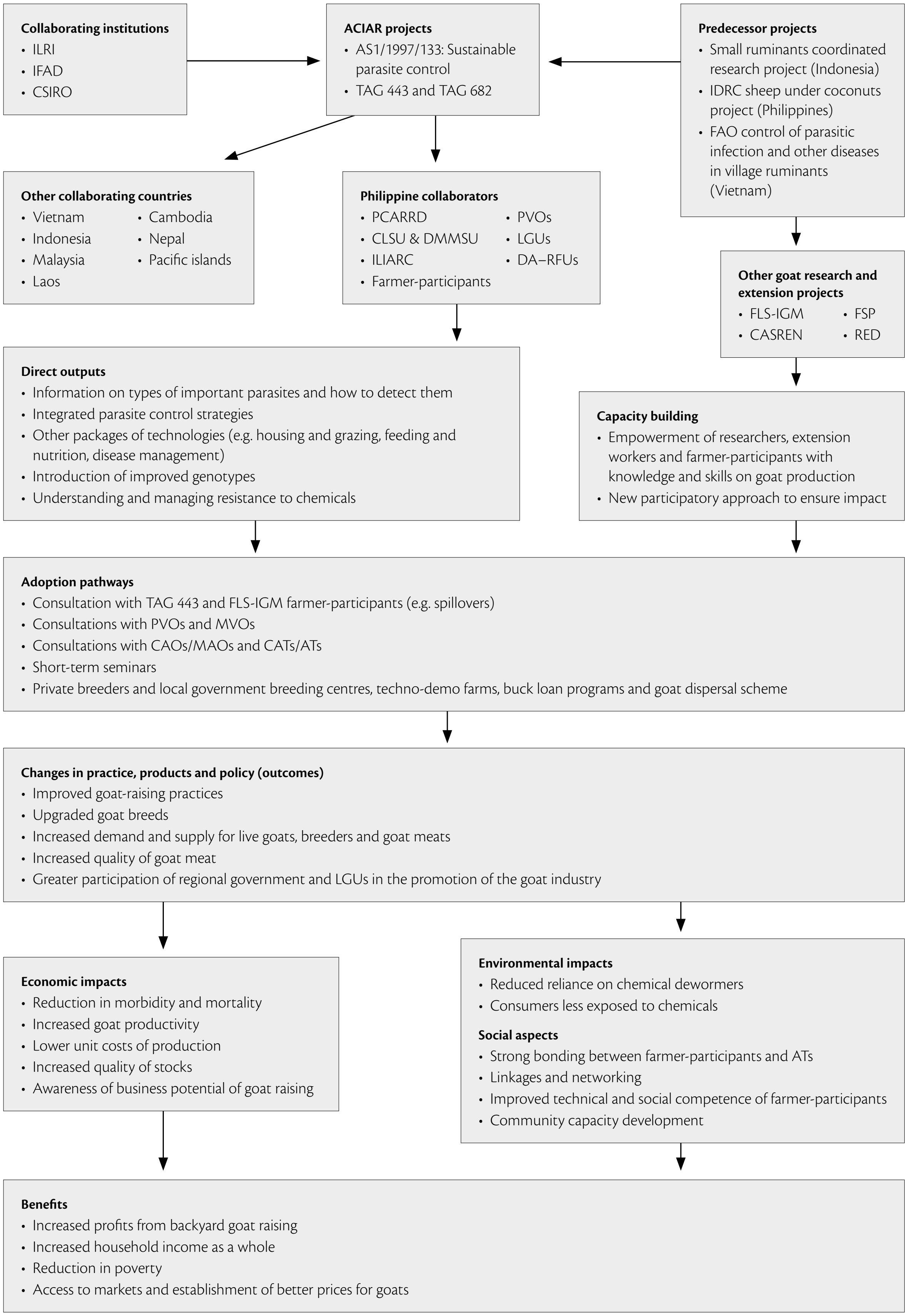

Figure 1. Summary of approach to impact assessment

by all agencies, and assumed that the research resources provided by each agency were equally efficient and earned the same average rate of return over the whole investment. By assuming that ACIAR shared in the benefits from the R&D in the same way as it shared in investment costs, an estimate was made of the net present value (NPV) of the ACIAR investment (and the investments of other partners). This approach required investments by the other agencies in the Philippines to be identified.

Second, the ACIAR and IFAD projects were not confined to either goats or the Philippines, creating further attribution issues. In addition, by confining attention to estimating the returns to investment in the Philippines, the total benefits from the research program are understated to the extent that the technology may spill over to partner countries and further afield.

2 Smallholder goat enterprises in the Philippines

2.1 Industry statistics

Goat farming in the Philippines is considered a sunrise industry. It requires low capital investment and realises high rates of return. Many government programs are focused on goat farming to improve incomes and livelihood, and to provide an opportunity to reduce poverty, especially among smallholders (DA–Livestock 2007).

Much chevon, or goat meat, is eaten by farm families, but there is increasing demand for it from consumers in the growing retail sector. While chevon is one of the highest priced meats in the retail markets, its supply in these outlets is not yet reliable. Consumption of goat meat has usually been restricted to special occasions. However, with the growing awareness that goat meat is a healthy food, the market for it is likely to expand. It has local and export potential as live animals, fresh or frozen chevon, value-added products, canned meat products, and goat milk and milk-based products (e.g. beauty preparations).

Based on 2006 data, China, India and Pakistan were the world's largest goat producers. Australia was the world's top goat-meat exporter, followed by China and France. The United States was the world's top importer of goat meat, followed by China and the United Arab Emirates (FAO 2007).

In the Philippines in 2006, livestock as a whole contributed PHP154.7 billion or about 17% to the total value of production of the agricultural sector (BAS 2006). Goat production was valued at PHP5.21 billion, contributing 3.4% of the value of the Philippine livestock industry (Table 2).

As of January 2007, the goat population in the Philippines was estimated at 4.0 million head. The number of goats slaughtered in 2006 was 2.5 million. From 1990, population and the number slaughtered increased at rates of 3.1% and 6.5%, respectively, but growth rates increased to 3.6% and 10.7%, respectively, from 2000, around the time that sustainable endoparasite control (SPC) technologies were first introduced. However, average live weight per head was falling over the same period, and hence the volume of goat meat produced grew much more slowly.[1]

Backyard farms account for almost all goat production in the Philippines—99.2% of total production in 2007. Backyard raisers usually consume the goats at home as daily fare and on special occasions. They also sell some of their goats in the market to augment income and pay school tuition fees, meet medical needs and fund essential farm inputs. Goat meat is rarely available in the wet markets, supermarkets, grocery stores, meat shops, restaurants or *carenderias* (small roadside canteens). Annual per capita consumption of goat meat has been a little over 0.3 kg since 2002.

1 This was most dramatic in 2006 when the number slaughtered increased, as did total consumption, yet total production fell markedly. The dramatic decline in average carcass weight may be explained by factors such as inbreeding and a demand from consumers for tender meat from young animals, but other unexplained factors must be at work here to cause changes so dramatic, perhaps including how BAS collects the data.

Goat numbers in the Philippines may grow at the rate of 10% in coming years, giving a population of about 8.8 million head in 2015 at an annual slaughter rate of 4.2 million head and per capita consumption of almost 1 kg (DA–Livestock 2007).

Farm-gate price at a national level increased from PHP57.13 per kg live weight in 2002 to PHP69.70 in 2006. In real terms, however, there was almost no trend in the farm price of goat, at about PHP72.00 per kg (derived by applying the consumer price index (CPI) for the Philippines given in the appendix to the nominal farm price in Table 2).

The largest regions for goats in 2007 were Region 6 (e.g. Iloilo) contributing 572,961 head or 14% of the national total, followed by Region 1 (e.g. Pangasinan) at 506,667 head or about 13%, Region 7 (e.g. Cebu) at 502,625 head or about 13%, Region 11 (e.g. Davao) at 372,608 or about 9%, and Region 4 A and B at 345,903 or almost 9%. These top five goat-producing regions accounted for almost 60% of the total goat production (BAS 2006).

Extension efforts related to SPC technologies were heavily focused on Regions 1 and 7, and this impact assessment therefore targeted those regions.

2.2 Economic impact of internal parasites on small ruminants

The most important parasites among goats include roundworms in the genera *Haemonchus* and *Trichostrongylus*, and a smaller proportion of *Strongyloides* and *Oesophagostomum* species. It is, however, difficult to estimate the current economic

Table 2. Philippines goat production and price statistics, 1992–2007

Year	**Population** ('000 head)	**Number slaughtered** ('000 head)	**Volume** ('000 t live weight)	**Value** (PHP million)	**Consumption** (kg/head)	**Farm price** (PHP/kg live weight)
1992	2,306	876	59.67	1,908		
1993	2,562	1,057	65.69	2,179		
1994	2,633	1,159	68.56	2,257		
1995	2,828	1,276	70.71	2,495		
1996	2,982	1,461	70.18	2,653		
1997	3,025	1,718	70.86	2,849		
1998	3,085	1,844	71.95	2,936		
1999	3,050	1,894	73.90	3,325		
2000	3,151	1,927	75.19	3,321		
2001	3,215	1,913	74.60	4,001		
2002	3,294	1,917	74.79	4,152	0.31	57.1
2003	3,270	1,893	73.83	4,440	0.30	58.9
2004	3,358	1,922	74.98	4,990	0.31	66.6
2005	3,535	2,062	77.29	5,110	0.32	65.7
2006	3,736	2,531	74.82	5,210	0.39	69.7
2007[a]	4,037		78.14	–		–

[a] As of January 2007

Source: BAS (1992–2007)

impact of internal parasites on small ruminants of the Philippines. The exact contribution of roundworm parasitism to annual mortality losses is large, but its economic value has rarely been estimated. Previous project reviews assumed that 15% of adult mortality, or 1% of adult goats, arises from roundworm-related diseases. The mortality rate among immature goats is even higher (Gray et al. 1999).

Selected studies of productivity in parasitised goats have been undertaken in southern Luzon. Que et al. (1995), reported in Gray et al. (1999), showed that, over an 8-month growth period, parasitised goats had a 4 kg weight deficit over unparasitised animals.

Howlader et al. (1997a,b,c) showed the significant pathological, parasitological and production changes occurring in immature goats infected artificially with *Haemonchus contortus* worms. The growth of newly born kids was adversely affected by mere infection of their mothers. Sani and Gray (2004) pointed out that, while smallholders might be well aware that parasites lead to sickness and death in goats, they might not know of the fertility losses they cause. They also noted:

> The broad spectrum anthelmintics in use are the benzimidazoles, levamisole and the macrocyclic lactones including Ivermectin. The benzimidazoles are most widely used because they are cheaper but there is an emerging resistance problem. 'Lumpy' packaging, cost and the unavailability in small villages constrain the use of anthelmintics.

McLeod (2004) gave US$3m as an estimate of the annual costs of roundworm parasitism in goats in the Philippines. These costs are due to goat mortality and meat loss.

3 Research undertaken

3.1 The ACIAR project

ACIAR project AS1/1997/133, *Sustainable endoparasite control for small ruminants in South-East Asia,* developed from an ACIAR-supported workshop on 'Sustainable parasite control', held in Bogor, Indonesia, in April 1996. The project initially ran for 3 years from 1 July 1998 – 30 June 2001, with a total anticipated investment of A$2.2m (including in-kind contributions from partners). The project was extended a further 2 years into mid 2003 at a further investment of ACIAR funds of A$407,193. The funds were used for salaries and operating expenses of CSIRO, ILRI and participating-country scientists. The project was coordinated by ILRI and PCARRD. Research was undertaken in the Philippines by Central Luzon State University (CLSU), Don Mariano Marcos Memorial State University (DMMMSU), DA Region 8 and the Bureau of Animal Industry (BAI); in Indonesia by the Research Institute of Animal Production and the Research Institute for Veterinary Science; and in Australia by CSIRO Livestock Industries. About one-third of total funds were invested in the Philippines.

The objectives of the original project, as specified in the project proposal documents, were to:

1. develop and test sustainable integrated endoparasite control strategies (including appropriate combinations of resistant hosts, strategic drenching and nutritional supplementation, and grazing management) applicable to smallholder farmers in South-East Asia
2. assess genetic variation in resistance to gastrointestinal nematode parasites in indigenous breeds/genotypes of sheep and goats, and develop protocols to enhance identification of resistant phenotypes in goats through the use of irradiated larvae
3. assess the extent of anthelmintic resistance in sheep and goat populations in South-East Asia using a larval development assay developed in Australia.

The main collaborators in Australia were Dr Leo Le Jambre, Dr Malcolm Knox and Dr Rob Woolaston of CSIRO Livestock Industries. In the Philippines the main collaborator was Dr Edwin C. Villar (PCARRD). Dr G.D. Gray and Dr G.M. Hood were employed by ILRI in the Philippines to oversee the project.

3.2 The ILRI–IFAD projects

'Development and testing of an integrated approach to the control of gastrointestinal parasites of small ruminants in south and Southeast Asia' (TAG 443) was an IFAD-funded sister project to the ACIAR project. The initial amount of the agricultural research grant was US$875,000 for a 4-year project from September 1999 to September 2003. The study was extended for another 2 years and was completed by 2005. The TAG 443 project covered the Asia–Pacific region, specifically the Philippines, Vietnam and Indonesia. Laos, Cambodia and Nepal also participated in the planning and review aspects but were allotted only small amounts of funding (ILRI–IFAD–PCARRD 2003). Again, it was estimated from discussions with the project group that about one-third of funds was spent in the Philippines.

Among the implementing institutions were ILRI, the National Agricultural Research System, the Food and Agriculture Organization of the United Nations (FAO), ACIAR, CSIRO Australia and the University of Tropical Agriculture Foundation.

The objectives of the project were:

- to reduce poverty among smallholder farmers in the South-East Asian countries through the improvement of small ruminant productivity
- through a participatory process, to promote the sustainable use of integrated parasite control to solve problems associated with endemic livestock disease.

Smallholder goat farmers, the primary stakeholders, actively participated in assessing the suitability of baskets of options most adaptable to their resources, capabilities and conditions.

For the TAG 443 project there were three focal sites, two in the province of Cebu (at Liloan and Danao) and one in Pangasinan (at Malasiqui). At each of these sites, a local working group was formed with representatives from the DA, the provincial veterinary office (PVO), the municipal/city agriculture office, the municipal/city planning and development office, and the village council (Gabunda et al. 2003). The working groups selected the cooperating farmers, of whom there were 16 in all. On-farm trials officially started in July 2001.

Cooperators were required to buy their stock and build pens etc. during the adoption of these technologies, but realised benefits from the project, through knowledge gained during the conduct of technology-based learning workshops (a major input). LGUs provided inputs such as dewormers and forage seeds at the start of the project to help ease farmers' financial burdens.

Cooperators designed their own goat-farming project in which they mixed and matched technological options that fitted with their perceptions, needs, resources and capabilities. The technologies were originally aimed at controlling worms but were developed into holistic approaches touching on all aspects of goat management. These improved techniques of goat production reduced mortality and morbidity.

TAG 682 was considered an extension of TAG 443 and entailed 'benchmarking' of available goat technologies such as nutrition and feeding. Implemented during 2004–06, total project costs were US$98,000.

3.3 Farmers' Livestock School

The Farmers' Livestock School (FLS) – Integrated Goat Management (IGM) project scaled-up the approach of TAG 443. Observing the benefits and gains that had been reaped from TAG 443 at Malasiqui, DA–Regional Field Unit (RFU) 1 sought expansion of these technologies to the whole Ilocos region.

The FLS was established in 2003, based on the same basket of technologies (e.g. complete confinement, partial confinement and rotational grazing) developed during the ACIAR and TAG 443 projects, but provided training to farmers over 6 months rather than 3 years. Using a condensed version of TAG 443, the FLS concepts and curriculum were tested at Balungao LGU over two cycles, using workshop methodologies developed by PCARRD, before implementing a fully operational FLS.

Following the curriculum of the TAG 443 process, technology options were repackaged into experience-oriented courses, with prepared session guides and technical handouts. In a 29-week course, the FLS focused on transforming farmers' backyard goat production into profitable enterprises. Through the so-called trainers' training, the FLS developed a core of regional facilitators who took FLSs to specific municipalities in their regions. Farmer-participants also co-shared resources with FLSs. Specifically, the farmer's equity included time and effort, animal stocks, cash for goat housing construction and the purchase of dewormers and medicines.

3.4 Other projects

Because of the apparent success of the ACIAR and IFAD projects, organisations such as PCARRD and DA funded a number of other projects to promote the development of the goat industry in the Philippines. It is difficult to separate the contributions of PCARRD and DA to each of these projects, and there is no objective way to apportion the adoption of the technology between projects. We have therefore attempted to identify the total investment in projects with a major focus on parasites in goats, and related this investment to total adoption of the parasite-control technologies. In our view, the only sensible approach to attribution would be on the basis of investment cost shares, which implies that each project and research provider has been equally efficient in earning returns to their investment.

We judged, based on discussions with stakeholders, that some projects, such as the 'Forages for smallholders project' (FSP) funded partly by AusAID, were unlikely to have contributed greatly to the adoption of parasite management in goats.

3.4.1 The Crop–Animal Systems Research Network (CASREN) projects

The CASREN project entitled 'Improving crop–livestock production systems in rainfed areas in Southeast Asia' was led by PCARRD in the Philippines and was supported by ILRI–ADB (Asian Development Bank). Dr Patricio Faylon (PCARRD) was a member of the steering committee. The project aimed to improve the productivity of rainfed crop–livestock systems run by smallholder farmers. The CASREN projects followed a similar approach to those of IFAD, with cooperating farmers trialling SPC technologies developed during the original ACIAR project but with perhaps a greater reliance on traditional extension methods. Capacity building in local government organisations seems to have been a key focus. The project's objectives were far broader than the management of internal parasites in goats.

In Phase I of the CASREN project (1999–2001), research and/or extension inputs on improved crop–livestock production systems were made to TAG 443 (2001–05) through Ms Marie Alo. She was reassigned from CASREN Phase I to TAG 443 as its overall project coordinator. There was thus a sharing of knowledge and skills. CASREN Phase II (2002–04) continued with training support to the extension workers and provided technical inputs such as packaging a comprehensive crop–livestock program. At the time of the Phase II report in October 2004 there were 477 partner-farmers testing specific technology options.

Due to these concerted research and extension efforts, another goat project, 'Enhancing smallholder goat production in Region I', was developed as an offshoot of the CASREN project (Datuin et al. 2005). It was a collaboration of the provincial and municipal LGUs and the DA–RFU 1, with the support of PCARRD, the Livestock Development Council, BAI, ILRI, CLSU and Region 1 state universities and colleges, and non-government organisations (NGOs).

3.4.2 RED project

In 2005, the 'Rural Enterprise Development' (RED) project, focusing on innovative goat-production systems, was implemented by the DA–Livestock Division and the DA–RFU 1. Funded by the Consultative Group on International Agricultural Research, the RED project was a collaborative undertaking of ILRI, DA–BAR and PCARRD. Other project partners were the provincial governments, LGUs and the farmer-participants. Specific aims of the RED project were to enhance production performance of goats by about 50% and improve the profitability of goat production in smallholder farms. A second RED project commenced in 2007, but it has a strong breeding focus and therefore little influence on this analysis.

3.5 Total expenditure on research

Many of the data on expenditure by ACIAR and partners on the original project (AS1/1997/133) were obtained from an April 1998 project submission. Data on the ACIAR contributions for 2001–02 and 2002–03 were obtained from the Centre's estimates of total project investment. These also indicated that the share of expenditure in the Philippines was 30%. We have assumed that the contributions of ILRI, CSIRO and PCARRD remained unchanged from 2001.

For projects with foreign partners, PCARRD's investments are mostly in-kind contributions. PCARRD's in-kind contributions to goat projects were assessed as a whole rather than project by project.

Investment data for the RED project were taken from an annual report (RED Technical Report No. 2) prepared for 2004–05. This document reports a total budget from ILRI of PHP2,452,156. In the absence of better information, we have averaged this over 3 years from 2005 and expressed it in Australian dollars—A$19,431 per year.

Investment data for TAG 443 were obtained from a project design document dated February 1999. We have included one-third of the IFAD budget over the course of the project, on the understanding that this was the share of funds invested in the Philippines. Funds from partners such as ACIAR and ILRI were not counted, on the understanding that these investments were already reflected in the ACIAR project funding details.

Investment data for TAG682 were obtained from its December 2006 completion report. The total ILRI–IFAD grant for this project was US$93,000 over the 3 calendar years 2004–06. The project was conducted in the Philippines, Indonesia, Vietnam and Lao PDR (with a small activity in Afghanistan). We have allocated the funds to financial years 2005–07 and, in the absence of better information, simply divided the budget equally among the four countries.

Sixteen FLSs conducted in Region 1 entailed a total investment of PHP582,257 as of July 2007. The average budget was about PHP36,391 per FLS site. Hence, the total cash budget for FLS trainings was estimated to be approximately PHP1.02m. Almost 50% of the total amount spent per site was provided by the host LGUs. DA–RFU 1 covered the costs of travel, field days, and supplies and materials expenses. Likewise, the PVO and other government offices such as the Department of Labor and Employment (DOLE) and the Technical Education and Skills Development Authority (TESDA) contributed. NGOs such as local goat-raisers' associations and barangay (village) councils contributed to the supply and material needs for the 29-week FLS sessions.

Data on real and nominal investments in Philippine pesos and Australian dollars by ACIAR, PCARRD and other investors are detailed in Table 3. Nominal expenditure was expressed in Australian dollars then deflated by the GDP deflator for Australia, taking 2007 as the base year. Exchange rate series were taken from the ACIAR impact assessment guidelines, and ACIAR's recommended interest rate of 5% was used to compound investment streams forward to 2007 (Gordon and Davis 2007). Similar procedures were applied to benefit streams.

Table 3. Investments made by ACIAR, PCARRD and partners in parasite management technologies

				Present value of R&D investments in 2007				
	ACIAR	**PCARRD**	**Other partners**	**ACIAR**	**PCARRD**	**Others**	**Total**	
	A$ nominal	PHP nominal	A$ nominal	A$ real	A$ real	A$ real	A$ real	PHP real
1999	59,964	2,294,976	405,500	117,719	178,647	796,058	1,092,423	42,210,948
2000	60,002	2,866,536	476,660	109,912	204,942	873,139	1,187,993	45,903,727
2001	59,845	2,935,036	530,960	99,651	185,309	884,138	1,169,098	45,173,631
2002	58,468	3,086,353	492,161	90,158	169,749	758,922	1,018,829	39,367,277
2003	63,690	4,054,953	426,736	90,822	164,490	608,525	863,837	33,378,441
2004		1,353,045	–	–	43,150	–	43,150	1,667,298
2005		2,347,125	33,069	–	67,187	39,821	107,008	4,134,751
2006		6,882,615	25,910	–	194,915	28,353	223,268	8,627,011
2007		3,375,045	30,522	–	87,346	30,522	117,868	4,554,394
	Present value (at 5% compounded)			508,262	1,295,735	4,019,478	5,823,473	225,017,476
	Share of total cost:			8.7%	22.3%	69.0%		

Using these processes, the present value of investment in the suite of R&D projects related to parasite control in goats is estimated to have been $A5.8m or PHP225m in 2007 terms. Investments by ACIAR and PCARRD were $A508,000 and PHP1.3m, respectively, giving them shares in total investment of 8.7% and 22.3%.

Our judgment is that, because of the significance of in-kind contributions and the difficulties of disentangling the reported budgets of overlapping projects, these estimates are more likely to overestimate than underestimate the total investment in R&D into parasite management in goats in the Philippines.

4 The outputs from the ACIAR, ILRI, IFAD and PCARRD projects

4.1 New knowledge, new skills and capacity building

The literature review of Gray et al. (1999) suggests that much was already known about the dimensions of the relationship between parasites and small ruminants in the Philippines. This knowledge had been gained from a range of research projects focusing on individual aspects of these dimensions. Perhaps this body of research could be described as being discipline focused. As described in section 3.1, the contribution of the ACIAR project arising from the Bogor conference was to apply a multidisciplinary research approach to developing an integrated, sustainable set of technologies to manage endoparasites in small ruminants (Alo 2004).

The ACIAR research was successful in identifying and developing a package of management strategies to control endoparasites that could be profitably applied by smallholders to reduce morbidity and mortality in goat production. The main element of this package seems to have been the confinement of goats, at least during periods of maximum parasite activity. Other elements not universally adopted included the use of anthelmintics, cut-and-carry feeding systems, rotational grazing and improved breeding stock based on an understanding of the epidemiology of parasites in goats in South-East Asian countries.

The sister IFAD project (TAG 443) that began in 2000 aimed to maximise on-farm practice change by encouraging cooperating farmers to choose and evaluate technologies from the options developed in the ACIAR project. According to Alo (2004), '…technology testing was farmer-planned, designed and managed'. Including local government extension staff, and particularly the local municipal planning officer, was a significant element in the approach, because goat production became a priority for municipal programs.

A review of the ACIAR project observed that it would be too simplistic to characterise the ACIAR input as being at the research end and the IFAD input closer to extension. There was overlap and close cooperation between the projects, with some scientists being involved in both projects.

The goat-management technologies developed through these projects all involve housing animals, at least at night and during inclement weather. Providing housing would seem to be an important capital constraint to adoption, although Alo (2004) argued that both material and labour costs were often low. All technology types involved the use of Anglo Nubian bucks (often loaned by the LGU), which have higher growth and reproductive rates (but which provide little gain in worm resistance) than other breeds. All technologies required the strategic use of anthelmintics a month before the rainy season in a manner designed to reduce the development of resistance.

During periods of housing, forage is cut and carried to the goats. Some of this forage may have natural anthelmintic properties. When goats are not housed, rotational grazing is encouraged to reduce exposure to worms by breaking their life cycle. All technology bundles made medicated urea–molasses mineral blocks available during the 2-month rainy season, to take advantage of increased resistance to worms from better nutrition.

Capacity building and training among stakeholders under TAG 443 were carried out through four formal training events covering participatory research and development, parasite-control techniques, monitoring and evaluation, and policy advocacy. There was also informal training through cross-project visits and meetings, regional and national workshops on technical aspects, and improved extension technologies. Initially, this involved 35 extension workers and 50 farmer-participants.

As noted above, TAG 443 led to the development of the FLS as a means of increasing the rate and extent of training in SPC technologies. As of December 2007, 49 FLSs had been held in 28 municipalities, with the total number of farmer-participants being 1,224.

As with the FLS, the outputs of the CASREN projects were usually extension oriented towards developing knowledge and skills among farmers about goat management. A process for capacity building was also developed. It included farmer orientation and field days, training seminars and field support. Sixteen training schools on goat–crop production system have been held, with 468 farmers and 74 extension workers participating as of 2003. There have also been field days and extension activities of a mass-media type.

The development of this participatory approach to R&D is regarded as a valuable outcome of the project. It is likely to be a particularly appropriate approach to enhance the adoption of knowledge-based technologies such as parasite control in goats, in contrast to technologies embodied in, say, a new grain variety or chemical, or in genetically superior breeding stock. It led to the development of capacity within PCARRD and DA to use this approach in other industries, and it is likely that those farmers who participated in this learning style have applied these principles to other farm and household activities. While no attempt has been made to value these outcomes here, discussions with stakeholders suggested that they may be significant.

According to the ACIAR project review report, there were about 12 undergraduate theses and one Masters dissertation related to this project undertaken at CLSU.

The project also released two software packages on its website. 'Tropical worm world' (TWW) detailed the dynamics of helminth populations and helped users assess the impact of resistance to anthelmintics on the control of worm parasites in pasture-based system. As a teaching and research tool, it allowed interactive exploration of the effects of weather, deworming and grazing management on worm burdens, but it has not otherwise been widely used.

The other software package, 'General livestock opportunities, risks and innovation analysis' (GLORIA), allowed the analysis of effects of a broad range of interventions on the dynamics of smallholder livestock herds. It was found to be particularly useful in showing not only the benefits of innovations but also the consequences, in terms of labour, changes in cash flow and risks. This proved to be an effective extension tool.

4.2 Adoption pathway

Much of the research was initially designed and carried out by scientists on techno demo farms, and was supported by research at CSIRO facilities in Australia. As already noted, this approach of providing intensive training to farmers was broadened in the FLS and CASREN projects and was the key means of promoting adoption of the integrated goat-management technologies.

A key component in promoting adoption was the use of what Alo (2004) refers to as the 'participatory technology development process' whereby cooperating farmers were involved in designing their project by making their own selections from the range of technology components available, managing their on-farm trials, providing the resources required for the technologies, and modifying the technologies to fit their resources and capabilities. Farmer-participants were further motivated by the FLS facilitators to mentor two or three neighbouring farmers, friends and/or relatives to effect a greater adoption rate within the region.

Information support systems included a website, written reports, databases and decision-making tools for extension workers and scientists. More specifically, a series of 11 technical advisory notes was developed describing the technologies, and a monograph was jointly published with ACIAR (Sani et al. 2004). The SParC Newsletter was published and research results were presented at national and international workshops. There is a catalogue of formal and informal publications on small ruminant parasites and goat production in various countries.

Most of the research and extension activities related to these projects were directed towards goat producers in Regions 1 and 7, and hence the impact assessment analysis reported here also focuses on these two regions. Data on goat numbers and production levels in the two regions are presented in Table 4. Goat numbers have risen markedly but, as noted earlier, production in terms of live weight has remained at around 20,000 tonnes per year because average carcass weight has fallen.

Table 4. Goat numbers, production and farm price in Regions 1 and 7

	Goat numbers			**Live-weight production** (tonnes)			**Farm price** (PHP/kg)
	Region 1	Region 7	Total	Region 1	Region 7	Total	Region 1
1999	361,699	459,523	821,222				80.43
2000	420,898	465,462	886,360	9,919	10,900	20,819	83.33
2001	437,145	492,123	929,268	9,527	10,519	20,046	84.04
2002	442,745	486,903	929,648	9,515	10,677	20,192	82.47
2003	456,791	444,745	901,536	9,103	10,653	19,756	83.97
2004	464,892	449,711	914,603	9,341	10,289	19,630	89.74
2005	479,002	476,806	955,808	9,968	10,738	20,706	96.35
2006	491,435	471,561	962,996	9,982	8,514	18,496	100.03
2007	508,341	502,625	1,010,966	10,022	8,271	18,293	106.24
2008	539,101	527,843	1,066,944				

5 Outcomes from research

The package of research and extension programs developed strategies to manage parasites in goats. This led, largely through reduced mortality in kids, to a significant reduction in the unit cost of producing goat meat and a steady increase in the adoption of the technology. The ongoing development of projects by national and municipal agencies to extend these technologies is evidence of the success of the earlier ACIAR-supported research.

5.1 On-farm impact

Limited information about the actual economic impacts of improved parasite management can be found in the TAG 443 report (ILRI–IFAD–PCARRD 2005), Alo (2004), the CASREN final report (Villar et al. 2004) and Brown et al. (2003).

Perhaps the most detailed analysis of the economic impact of parasites in goats in the Philippines was that conducted by Brown et al. (2003). They focused on the financial performance of the 16 cooperating farmers in the TAG 443 project, in what was effectively a case-study approach. They used partial budgeting to estimate the change in farm income before and after the technology was adopted. In-kind contributions of family labour, and materials and drenches provided by local government, were valued. Production parameters were those experienced by the individual farmers.

Brown et al. (2003) found the technology mixes generated significant improvement in farmers' annual incomes, ranging from about PHP5,000 to PHP17,000. Alo (2004) provided some data on the on-farm impacts of the technologies. As of January 2001, it appears that average flock size had almost doubled, morbidity had fallen from 53% to 2% and mortality from 56% to 2%. Alo noted positive changes in a net income measure.

The TAG 443 report recorded the following impacts:

- There was an increase in average herd size, from 8 to 26.
- Mortality fell from 67% to just over 3%. This was over almost 2 years from the start of 2001 to December 2002.
- Morbidity fell from 50% to 6%.
- Odour and fly numbers were reduced because of better management of manure.
- The net average income from goat production rose from \$77 to \$170.
- There were improvements in social competence, including farmer-to-farmer extension activities.

In the course of this impact assessment, an estimate was made of the change in the unit cost of producing goat meat, based on past research findings, the judgment of industry experts and the findings from a survey conducted during the impact assessment. The comparison was made between a 10-doe herd using traditional management practices and the same size flock using SPC technology with complete confinement. A major difference between the two is the cash outlay that technology adopters must make on housing, labour, concentrated feed, and drugs and mineral supplements to minimise the incidence of parasitism.

The technology results in a significant reduction in kid mortality (from 67% to 3%) and hence delivers more young goats for sale each year. The introduction of superior goat breeds also increased the average live weight at market age. This translates to higher production, hence higher revenue. In the computation of gross profit, opportunity costs on some resources were taken into consideration. For example, though most goat houses were constructed using 'free' locally available materials, the gross margin computation included an imputed cost for these materials.

An imputed value was also included for the extra land and forage required by the larger number of goats in a 10-doe herd even though they are confined. Under traditional technology, 1 hectare of land is required to feed and sustain 15 goats. We found during our survey that farmers currently gather forage free of charge from idle lands, but the opportunity cost of this practice is likely to become more obvious as the technology is more widely adopted. It would not seem sensible to assume that the new technology requires less 'land' and forage. We have imputed a rental value of PHP4,800 per hectare on the land used by goats, based on the net income from using this land to grow rice.

Supplies of veterinary medicines were also valued even though these were often provided free to the farmers by the LGU.

The budget presented in Table 5 was developed using costs in 2007 and a price for goat meat of PHP100 per kg. The unit cost of producing goat meat was estimated to be almost PHP10 per kg lower under the SPC technology. When related to a price of PHP100 per kg, this gives an estimate of the *k*-shift (supply shift) of 9.3% (reflecting an assumption that, in equilibrium, the product price equals the average cost of production).

We have treated the goat industry as having no interactions with other farm enterprises. However, some positive interactions include better management of

Table 5. Enterprise budget for a 10-doe goat herd

	Extensive	**Complete confinement**
Revenue (surplus goats) (PHP)	12,672.00	46,560.00
Operating costs (PHP)		
Culled does	(6,000.00)	(6,000.00)
Depreciation (housing)	333.33	1,531.20
Buck service	1,500.00	1,500.00
Labour	3,600.00	7,200.00
Concentrated feed		5,990.40
Veterinary medicines		1,164.00
Medicated urea–molasses mineral blocks		3,234.82
Replacement does	4,000.00	4,000.00
Land rental	5,734.40	10,649.60
Light and water	200.00	800.00
Total costs	**9,367.73**	**30,070.02**
Operating profit	**3,304.27**	**16,489.98**
Amount of goat meat produced (kg)	126.7	465.6
Production cost per kg	73.92	64.58
Reduction in production cost per kg	13%	
k-shift	9.3%	

Sources: Based on Datuin (2007), PCARRD:DOST, DA–BAR (2006), PCARRD (2007) and field interviews agricultural by-products, with goats converting plant waste into proteins of higher value, and goat manure composted into organic fertilisers for use in farmers' fields. Negative spillovers can also, no doubt, be readily envisaged but, because the positive and negative spillovers are likely to be small, we have not valued them.

It is also worth noting that we have classified all training costs as part of the R&D investment budget. Our judgment is that much of the training has been conducted with groups of farmers and that little of the technology has been delivered one-on-one to farmers, tailored to their individual circumstances. Had the technology been delivered in the latter mode, it may have been more appropriate to treat the delivery cost as a production expense appearing in the budget above, thus reducing the size of the *k*-shift but also reducing the R&D investment budget.

5.2 Evidence on adoption

Assessing the rate and extent of adoption of parasite-control innovations in goats is complex because, rather than a single technology, a package of technologies that farmers can choose from is involved. When farmers do not adopt the full package, a judgment is required about whether or not they can be classed as adopters. In previous analyses, such as that of Brown et al. (2003), alternative management packages were compared. All of these involved some degree of confinement of goats; hence, it would seem that the characteristic that defines whether or not smallholders have adopted parasite control technologies developed through the ACIAR and related projects is that they at least partially confine their goats for endoparasite control.

The estimated adoption rates shown in Table 6 were largely based on the number of farmers who participated in FLS, CASREN and TAG 443 training. BAS data were available on the goat inventory in Regions 1 and 7 (Table 4). We also assumed that the farmer-participants trained or influenced three of their neighbours or friends, as was expected of participants and was supported by survey results. Based on survey findings, farmer-adopters have flocks of about 10 does or a total flock of about 43 animals. Flock structure was derived from application of the GLORIA software package.

Finally, the adoption rate was estimated as the ratio of the total number of goats held by farmer-adopters to the total number of goats in Regions 1 and 7 as derived from BAS statistics. Following this approach, the adoption rate in Regions 1 and 7 grew from 0.01% in 2001 in 28.7% in 2007.

Adoption beyond 2007

We expect adoption to continue to grow in Regions 1 and 7. In part this arises as the technology spills over from adopters to their neighbours.

A more important source of increased adoption, however, is the continuing investment by PCARRD, DA and LGUs in extension activities. These investments are

Table 6. Adoption rate

Year	Cumulative number of technology adopters	Total goat inventory of technology adopters[a]	Estimated adoption rate (%)
2001	64	640	0.01
2002	724	8,008	1.18
2003	1,232	21,904	3.26
2004	2,768	53,048	7.77
2005	3,468	90,020	12.86
2006	5,920	146,212	20.73
2007	7,224	209,620	28.72

[a] Based on the results of GLORIA (see text)

essential since the technology is knowledge based. There is a need to continuously train farmers and refresh their knowledge of goat management. Some important features of the technology are also lost if spillover between neighbours is the only method for information dissemination. Based on existing extension programs and the high priority given to the development of the goat industry by PCARRD, DA and LGUs, we expect that expenditure on parasite management technologies in the industry in Regions 1 and 7 will continue at the rate of PHP3.5m per year to 2030.

In this scenario, based on the observed rate of adoption in recent years, we expect the adoption rate to reach 75% by 2015 and remain there to 2030. This rapid growth in adoption is achievable for a number of reasons.

First, part of the government investment will go to the 'Training of trainers' program, in which representatives of several municipalities will undergo training in FLS facilitation. These participants will subsequently conduct FLS classes funded by the LGU in their respective home towns. The resulting FLS graduates will then instruct at least three other farmers in the SPC technology. The scheme should result is an exponential growth in the number of technology adopters.

The second reason for the growth of adoption is the rapid increase in the herd size of adopters. Participants who start with four does usually do not sell the female goats. Their objective is to increase the herd size until it reaches the maximum capacity of the house and grazing area. It usually takes only 2 years for a goat raiser to triple his goat inventory. Hence, adopters have larger herds than non-adopters, and the proportion of goats under the technology will be larger than the proportion of farmers who adopt the technology.

Third, goat milk production is starting to be recognised as a promising venture. This lucrative industry encourages more farmers to go into goat raising. Optimal milk production can be achieved with the help of the SPC technology.

Finally, the continuing importation of goats from Australia, New Zealand and the USA will further improve the performance of the goat industry for years to come.

5.3 Environmental consequences

There seem to be few significant environmental drawbacks associated with the technologies developed for endoparasite control in goats through the ACIAR and related projects. Anthelmintics have never been widely used, presumably because of their cost. Perhaps it could be argued that the ACIAR and related projects forestalled the abuse of anthelmintics, thus reducing the rate of development of resistance to drugs, with benefits to human and environmental health. This benefit is somewhat offset if drug use increases with the growth of the industry.

Environmental consequences may become more significant if there is pressure on publicly held land and forests for the forage used in goat production.

6 Impact assessment

6.1 Welfare analysis of project benefits

The benefits from new technology packages that give better control of parasites in goats were estimated using standard welfare (economic surplus) analysis, as described in detail in, for example, Alston et al. (1995). In a static supply and demand model (Figure 2) the impact of better parasite control is modelled as a reduction in the unit cost of producing goat meat of *bc* pesos at the initial equilibrium level of production, Q_0. Assuming this technology results in the same savings in costs at all levels of production gives a downward shift (k), from S_0 to S_1, in the supply of goat meat at the farm level. This results in an increase in farm live-weight production from Q_0 to Q_1 and a fall in the farm price of goat meat from P_0 to P_1.

The gains (surpluses) to producers (ΔPS) and consumers (ΔCS) (including processors and traders) are represented by the areas *efcd* and *abfe*, respectively, and described by the equations (Alston et al. 1995):

$$\Delta PS = (K - Z) P_0 Q_0 (1 + 0.5 Z \eta) \quad (1)$$

$$\Delta CS = P_0 Q_0 Z (1 + 0.5 Z \eta) \quad (2)$$

where

$K = k / P_0$

$Z = K\varepsilon / (\varepsilon + \eta)$

ε is the elasticity of supply at the farm level

η is the absolute value of the elasticity of demand at the farm level.

Total industry welfare gains are the sum of the changes in producer and consumer surpluses. The distribution of gains between the two depends crucially on relative demand and supply elasticities.

6.2 Parameter values used in modelling welfare changes

6.2.1 An estimate of the *k*-shift

As described earlier (section 5.1), the baseline analysis of changes in welfare was based on a *k*-shift of 9.3%.

6.2.2 Demand and supply parameters

We have used demand and supply elasticities that are based on our knowledge of the goat industry. Econometric estimates are unavailable. In our judgment the adoption of this technology has had little impact as yet on the price of goat meat. In this analysis we have thus used a highly elastic demand (–5.0) for goat meat. The qualification to this argument is that goat meat is a specialty, high-priced commodity that consumers might regularly purchase only if its price were substantially lower. A further qualification is that some survey respondents reported price effects from increased production in isolated markets.

Econometric estimates of supply response for livestock are notoriously low, often less than 0.3. The judgment of industry experts is that producers have a greater incentive and capacity to increase production once their ability to control parasites improves. We have therefore assumed a supply elasticity of 1.0.

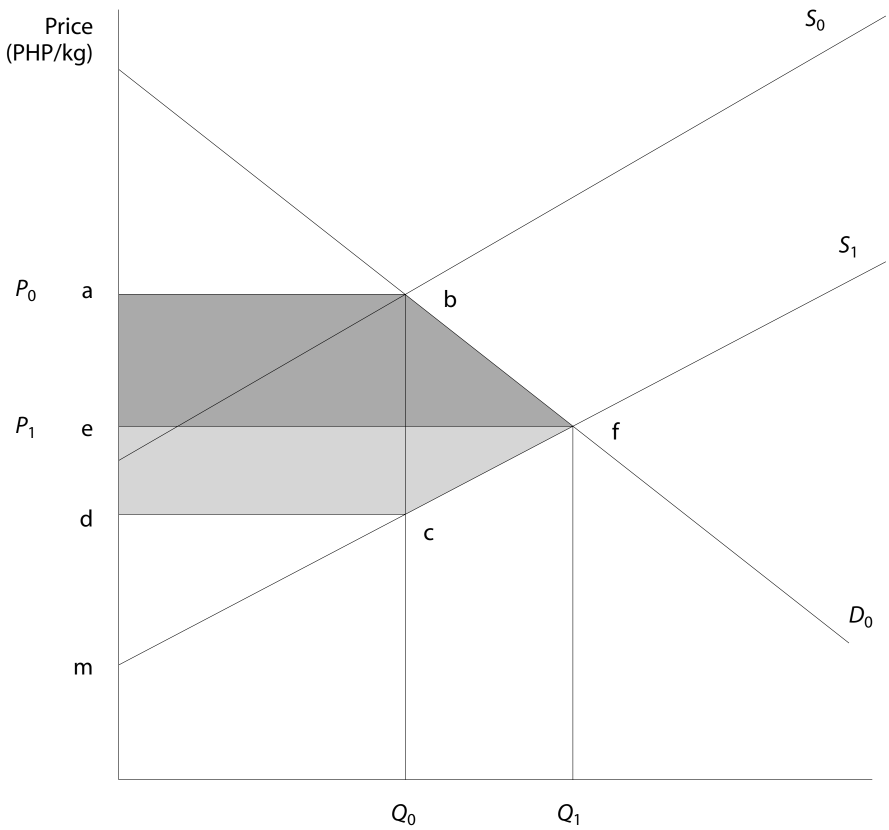

Figure 2. Welfare changes from parasite control in goats

6.2.3 Equilibrium price and quantity

Equations (1) and (2) indicate that welfare effects are significantly influenced by the choice of product price and quantity. Welfare analysis of the type applied here is generally conducted using prices and quantities judged to be those existing when the industry is in equilibrium. Of course, the industry is never in equilibrium, so analysts must make a judgment. When conducting an ex-ante evaluation of technology, a common approach has been to use recent industry history as a basis for selecting equilibrium prices and quantities. The prices and estimates of welfare changes are regarded as being real (rather than nominal) and projected forward over the period of the analysis, disregarding other exogenous impacts on the industry that will likely qualify the actual benefits accruing.

In an ex-post analysis such as that presented here, the difficulties and consequences of the choice of price and quantity are clearer. One could choose the price and quantity pertaining to when the technology was first adopted or those at the time the analysis was conducted. Alternatively, and perhaps ideally, one could attempt to estimate the welfare effects in each year since the technology was first adopted. This would, however, likely require an econometric approach to isolate the impacts of exogenous influences other than the new technology on the goat industry, with one consequence being a much more expensive welfare analysis.

Here the analysis has been conducted from the viewpoint of the industry in 2007 rather than around 2000. An important reason for doing this is that the difference in production costs between the two technologies can be more accurately estimated. If 2000 were chosen, an attempt would need to be made to replicate practices and prices pertaining then.

Another dimension to the choice of equilibrium price is that, in the approach used here, *k*, the supply shift, is estimated to be the change in unit production costs as a proportion of product price. This is based on the assumption that price in equilibrium is equal to the long-run average cost of production. If the adoption of the technology has had a price impact, then *k* may be overestimated, and perhaps the technology itself may have been modified. Simultaneously, there are likely to have been other positive and negative influences on price and the technology.

In the case of the goat industry in the Philippines, there has been no discernible trend in the real price of goats at the farm level since 2002, providing some justification for the pragmatic approach adopted here of basing the welfare analysis on prices, quantities and production costs experienced in years close to 2007. The estimates of welfare change from this approach were applied back to 2002 and forward to 2030.

BAS statistics suggest that the price (in 2007 pesos) of goat meat has remained at around PHP70 per kg since 2002. A recent survey conducted as part of this impact assessment found, however, that farmers in Regions 1 and 7 have been receiving a price of about PHP100 per kg, and this price has been used in this analysis. Perhaps this higher price reflects local supply and demand conditions or the higher quality of goats produced using the technologies described here.

Annual production of goat meat in Regions 1 and 7 (Table 4) has typically been about 20,000 tonnes.

6.2.4 The extent of adoption of the technology

The process used to estimate adoption was described earlier (section 5.2). From 2001 to 2007 the level of adoption grew to almost 30% (Table 6) and we expect it to grow to 75% by 2015. A second scenario considered below is one in which adoption is held at its current level, as is investment—an ex-post scenario.

The fact that the technology has been not been adopted by all producers in Regions 1 and 7 (nor in the rest of the Philippines) raises important methodological issues for welfare analysis. Those who do not adopt the technology will be worse off if the price falls as industry production expands. Davis (1994) advocates that, in this circumstance, the separate welfare effects on adopters and non-adopters be explicitly modelled, whereas the usual practice is to apply an adoption rate to the *k*-shift in a single market.

These issues would become even more complex if an attempt were made to estimate welfare effects in series of particular years in an ex-post analysis.

Here we have adopted the usual pragmatic approach of first estimating total potential welfare changes for a *k*-shift of 9.3% if all goat producers in Regions 1 and 7 to adopt the technology. Then actual welfare gains were assessed by applying the estimated adoption rate. This approach can be partly justified by our judgment that the price effect from the current level of adoption of the technology has been small.

6.3 Financial analysis

Solving the model above for a 9.3% *k*-shift and the other parameter values, the annual potential welfare gain to the Philippines from adoption of the parasite control technologies by all goat producers in Regions 1 and 7 is PHP194m (A$5m) in 2007 values, with 83% of the benefits accruing to goat producers.

To estimate the actual welfare gains, the annual potential benefits were projected forward to 2030 and adjusted by the estimated rates of adoption of the technology. In our baseline scenario with continued investment in R&D to 2030, adoption grows from just under 30% in 2007 to 75% in 2015 and remains at that level until 2030. In 2030, the future stream of benefits is converted to a perpetuity by dividing by the interest rate. The stream of future benefits is discounted at a rate of 5% to a present value in 2007 as recommended in the ACIAR impact assessment guidelines (Gordon and Davis 2007).

The present value of benefits to the Philippines amounts to PHP2,800 m (A$73m) (Table 7). The present value of investment in the research is PHP270m (A$7m). This investment was made by ACIAR, PCARRD and other partners. Hence, the NPV of the investment was PHP2,530m (A$66m). The benefit:cost ratio was 10.4:1 and the IRR almost 25%.

The investment by ACIAR was A$0.5m (2007) and its share of the total investment was 7.3%. Attributing ACIAR with an equivalent share of the benefits gives a NPV of its investment of A$4.8m, a benefit:cost ratio of 10.4:1 and an IRR approaching 25%.

Table 7. Present value of investment and revenue streams

	Real investment		Adoption rate	Present value of estimated welfare gains (2007)					
				Producer surplus		Consumer surplus		Total surplus	
	A$m	PHPm	%	A$m	PHPm	A$m	PHPm	A$m	PHPm
1999	1.1	42.2							
2000	1.2	45.9							
2001	1.2	45.2	0.00	0.0	0.2	0.0	0.0	0.0	0.2
2002	1.0	39.4	0.01	0.1	2.4	0.0	0.5	0.1	2.9
2003	0.9	33.4	0.03	0.2	6.4	0.0	1.3	0.2	7.7
2004	0.0	1.7	0.08	0.4	14.5	0.1	2.9	0.5	17.5
2005	0.1	4.1	0.13	0.6	22.9	0.1	4.6	0.7	27.5
2006	0.2	8.6	0.21	0.9	35.2	0.2	7.0	1.1	42.2
2007	0.1	4.6	0.29	1.2	46.4	0.2	9.3	1.4	55.7
2008	0.1	3.2	0.36	1.4	55.1	0.3	11.0	1.7	66.2
2009	0.1	3.0	0.44	1.7	65.1	0.3	13.0	2.0	78.1
2010	0.1	2.9	0.51	1.8	71.0	0.4	14.2	2.2	85.2
2011	0.1	2.8	0.58	2.0	77.8	0.4	15.6	2.4	93.3
2012	0.1	2.6	0.65	2.1	83.0	0.4	16.6	2.6	99.5
2013	0.1	2.5	0.71	2.2	85.6	0.4	17.1	2.7	102.7
2014	0.1	2.4	0.74	2.2	85.4	0.4	17.1	2.7	102.5
2015	0.1	2.3	0.75	2.1	82.1	0.4	16.4	2.5	98.5
2016	0.1	2.2	0.75	2.0	78.2	0.4	15.6	2.4	93.8
2017	0.1	2.1	0.75	1.9	74.5	0.4	14.9	2.3	89.4
2018	0.1	2.0	0.75	1.8	70.9	0.4	14.2	2.2	85.1
2019	0.0	1.9	0.75	1.7	67.5	0.3	13.5	2.1	81.1
2020	0.0	1.8	0.75	1.7	64.3	0.3	12.9	2.0	77.2
2021	0.0	1.7	0.75	1.6	61.3	0.3	12.3	1.9	73.5
2022	0.0	1.6	0.75	1.5	58.4	0.3	11.7	1.8	70.0
2023	0.0	1.5	0.75	1.4	55.6	0.3	11.1	1.7	66.7
2024	0.0	1.5	0.75	1.4	52.9	0.3	10.6	1.6	63.5
2025	0.0	1.4	0.75	1.3	50.4	0.3	10.1	1.6	60.5
2026	0.0	1.3	0.75	1.2	48.0	0.2	9.6	1.5	57.6
2027	0.0	1.3	0.75	1.2	45.7	0.2	9.1	1.4	54.9
2028	0.0	1.2	0.75	1.1	43.5	0.2	8.7	1.4	52.3
2029	0.0	1.1	0.75	1.1	41.5	0.2	8.3	1.3	49.8
2030	0.0	1.1	0.75	20.4	789.9	4.1	158.0	24.5	947.9
Total (PV)	**6.9**	**270.2**		**60.5**	**2,335.8**	**12.1**	**467.2**	**72.5**	**2,803.0**

Table 7. (continued)

	Australia	Philippines
Benefit:cost ratio	10.4:1	10.4:1
Internal rate of return (%)	24.7	24.7
Net present value	**A$ million**	**PHP million**
Total	65.5	2,532.8
ACIAR	4.8	
ACIAR cost share	7.3%	

We have confined this scenario to increased adoption in Regions 1 and 7 but there may be opportunities to profitably extend the technology to other parts of the Philippines. Recall also that those goat farmers who do not adopt the technology will lose if the adoption of the technology causes the price of goats to fall.

A more conservative second scenario, an ex-post scenario, is to hold investment and adoption at their 2007 levels. The welfare changes associated with this scenario are presented in Table 8. As expected, the financial criteria are not quite as strong, with a benefit:cost ratio of 5.6:1, an IRR of 19% and a NPV of $A26.5m (PHP1,025m). The NPV of benefits from the ACIAR investment (its cost share is 8.7%) is A$2.3m.

Table 8. Present value of investment and revenue streams: ex-post scenario

	Real investment		Adoption rate	Present value of estimated welfare gains (2007)					
				Producer surplus		Consumer surplus		Total surplus	
	A$m	PHPm	%	A$m	PHPm	A$m	PHPm	A$m	PHPm
1999	1.1	42.2							
2000	1.2	45.9							
2001	1.2	45.2	0.00	0.0	0.2	0.0	0.0	0.0	0.2
2002	1.0	39.4	0.01	0.1	2.4	0.0	0.5	0.1	2.9
2003	0.9	33.4	0.03	0.2	6.4	0.0	1.3	0.2	7.7
2004	0.0	1.7	0.08	0.4	14.5	0.1	2.9	0.5	17.5
2005	0.1	4.1	0.13	0.6	22.9	0.1	4.6	0.7	27.5
2006	0.2	8.6	0.21	0.9	35.2	0.2	7.0	1.1	42.2
2007	0.1	4.6	0.29	1.2	46.4	0.2	9.3	1.4	55.7
2008			0.29	1.1	44.2	0.2	8.8	1.4	53.1
2009			0.29	1.1	42.1	0.2	8.4	1.3	50.6
2010			0.29	1.0	40.1	0.2	8.0	1.2	48.1
2011			0.29	1.0	38.2	0.2	7.6	1.2	45.9
2012			0.29	0.9	36.4	0.2	7.3	1.1	43.7
2013			0.29	0.9	34.7	0.2	6.9	1.1	41.6

Table 8. (continued)

	Real investment		Adoption rate	Present value of estimated welfare gains (2007)					
				Producer surplus		Consumer surplus		Total surplus	
	A$m	PHPm	%	A$m	PHPm	A$m	PHPm	A$m	PHPm
2014			0.29	0.9	33.0	0.2	6.6	1.0	39.6
2015			0.29	0.8	31.4	0.2	6.3	1.0	37.7
2016			0.29	0.8	29.9	0.2	6.0	0.9	35.9
2017			0.29	0.7	28.5	0.1	5.7	0.9	34.2
2018			0.29	0.7	27.2	0.1	5.4	0.8	32.6
2019			0.29	0.7	25.9	0.1	5.2	0.8	31.0
2020			0.29	0.6	24.6	0.1	4.9	0.8	29.6
2021			0.29	0.6	23.5	0.1	4.7	0.7	28.1
2022			0.29	0.6	22.3	0.1	4.5	0.7	26.8
2023			0.29	0.6	21.3	0.1	4.3	0.7	25.5
2024			0.29	0.5	20.3	0.1	4.1	0.6	24.3
2025			0.29	0.5	19.3	0.1	3.9	0.6	23.2
2026			0.29	0.5	18.4	0.1	3.7	0.6	22.1
2027			0.29	0.5	17.5	0.1	3.5	0.5	21.0
2028			0.29	0.4	16.7	0.1	3.3	0.5	20.0
2029			0.29	0.4	15.9	0.1	3.2	0.5	19.1
2030			0.29	7.8	302.4	1.6	60.5	9.4	362.9
Total (PV)	**5.82**	**225.02**		**18.30**	**706.98**	**3.66**	**141.40**	**32.36**	**1250.34**

	Australia	Philippines
Benefit:cost ratio	5.6:1	5.6:1
Intenal rate of return (%)	19.0	19.0
Net present value	A$m	PHPm
Total	26.5	1025.3
ACIAR	2.3	

A third scenario we chose to examine was one in which the cost reduction was larger than our aforementioned budget estimates. If the *k*-shift were 10% higher at 10.3%, total annual potential welfare gains would increase to PHP214m (A$5.6m). Under the baseline scenario, where the level of adoption increased to 75%, the benefit:cost ratio would rise to 11.5:1, the IRR to 26% and the NPV to A$73m (PHP2,825m). Were the adoption rate to remain at 30%, the benefit:cost ratio would be 6.1:1, the IRR 20% and the NPV $A30m (PHP1,156m).

The financial criteria for the three scenarios are summarised in Table 9.

Table 9. Financial criteria for three scenarios

		Scenario		
		Baseline	Ex post	Big *k*
Benefit:cost ratio		10.4:1	5.6:1	11.5:1
Internal rate of return (%)		24.7	19.0	26.0
Net present value	A$m	65.5	26.5	73.0
	PHPm	2,533	1,025	2,825

7 Conclusions and lessons

There has been an ongoing program of research and extension into the management of endoparasites in goats in the Philippines. The program began with an ACIAR-funded project that applied a multidisciplinary research approach to developing an integrated and sustainable set of technologies to manage endoparasites in small ruminants. The ACIAR research was successful in identifying and developing a package of management strategies to control endoparasites, which could be profitably applied by smallholders to reduce goat morbidity and mortality. The main elements of this package were the confinement of goats, at least in periods of maximum parasite activity, and the strategic use of anthelmintics.

Later projects, partly funded by IFAD, ILRI and PCARRD, aimed to maximise on-farm practice change by encouraging cooperating farmers to choose and evaluate technologies from the options developed in the ACIAR project. The package developed to manage endoparasites is management- or information-based rather than embodying a discrete innovation such as a new chemical or a higher yielding genotype. It is likely that this characteristic of the package will mean that adoption will be hard won despite the potentially large on-farm economic advantages flowing from its implementation. A feature of the projects proceeding from the original ACIAR project was the refining and shortening of farmer participatory research and training techniques that were finally delivered through the FLS process. Nevertheless, as is evident from the experience reported here, gaining adoption of such information-based technologies is slow and expensive. On the other hand, the technology package is likely to remain relevant over a longer period, and farmers are likely to have an enhanced capacity to apply these decision-making processes more generally on their farms.

Because of the potential of the technology to improve the livelihood of smallholders, national agricultural institutions and local governments have continued to fund extension programs related to parasite control in goats. The total investment in these programs in 2007 values was A$5.8m (PHP225m) to 2007. If the Philippine agencies continue to invest in extension related to this technology at the rate of PHP3.5m per year (as in 2007), the present value of the total investment to 2030 will amount to PHP270m (A$7m).

The technology results in a large reduction in mortality in goat kids, from about 70% to less than 5%, and leads to many more surplus goats for sale. We estimated that, even after allowing for extra housing, labour and forage costs, the unit cost of producing goat meat fell by almost PHP10 per kg live weight in 2007, giving a *k*-shift of –9.3% when the farm price of goat meat is PHP100 per kg, as has been the case in recent years.

Extension of the technology focused on Regions 1 and 7, where annual production has been steady at around 20,000 tonnes in recent years (although goat numbers have increased markedly). Under this scenario, the annual potential welfare gain to the Philippines from adoption of the parasite control technologies by all goat producers in Regions 1 and 7 is PHP194m ($A5m) in 2007 values, with 83% of these benefits accruing to goat producers.

A key means of promoting adoption has been a series of farmer livestock schools run through a number of programs funded by PCARRD and local authorities. Based on attendance at these schools and on a survey conducted during the course of the impact assessment, we estimate that, since 2001, the rate of adoption has grown to almost 30% among goat producers in Regions 1 and 7. At the projected rate of investment in extension, and based on past rates of adoption, we expect that adoption will grow to 75% by 2015 and remain at that level until 2030.

Projecting these benefits forward to 2030 and applying the adoption rate described above, the present value of benefits to the Philippines amounts to PHP2,800 m (A$73m). Recall that the present value of investment in the research is expected to be PHP270m (A$7m) to 2030. This investment was made by ACIAR, PCARRD and other partners. Hence, the NPV of the investment is PHP2,530m (A$66m). The benefit:cost ratio is 10.4:1 and the IRR almost 25%.

The investment by ACIAR was A$0.5m, which amounted to 7.3% of the total investment in this program of research and extension. Attributing benefits to ACIAR at this rate gives a NPV to the ACIAR investment of A$4.8m.

This has been a profitable investment by ACIAR and its Philippine and international partners, contributing to poverty alleviation among livestock smallholders in the Philippines. The analysis has been conducted under a conservative set of assumptions. Even holding investment and adoption at 2007 levels, an ex-post scenario, gives a strong level of financial return—the benefit:cost ratio is 5.6:1, the NPV PHP1,025m (A$27m) and the IRR 19%. The NPV to ACIAR under this scenario is A$2.3m.

A third scenario we chose to examine was one in which the cost reduction was larger than our budgeted estimates. If the *k*-shift were 10% higher, at 10.3%, total annual potential welfare gains would increase to PHP214m (A$5.6m). Under the baseline scenario where the level of adoption increased to 75%, the benefit:cost ratio rose to 11.5:1, the IRR to 26% and the NPV to PHP2,825m (A$73m). Were the adoption rate to remain at 30%, the ex-post scenario, the benefit:cost ratio would be 6.1:1, the IRR 20% and the NPV PHP1,156m (A$30m).

The delivery of this information-based technology for managing parasites through intensive training schools and participatory research on farms was seen as not only important to achieving its adoption among goat farmers but also in building human capacity among farmers and research and extension workers. The farmer-adopters have increased capacity to apply, in other farm enterprises, the principles they have learned. There is a greater capacity within PCARRD, the DA and local government to deliver complex technologies through this participatory research and training approach.

8 References

Alo A.M.P. 2004. Developing and testing integrated approaches to sustainable parasite control in small ruminants with farmers in the Philippines, Vietnam and Indonesia. Pp. 35–50 in 'Worm control for small ruminants in tropical Asia', ed. by R.A. Sani, D.G. Gray and R.L. Baker. Monograph No. 113. ACIAR: Canberra.

Alston J.M., Norton G.W. and Pardey P.G. 1995. Science under scarcity: principles and practice for agricultural research evaluation and priority setting. Cornell University Press: Ithaca and London.

BAS (Bureau of Agricultural Statistics) 1992–2007. Goat industry performance reports. Department of Agriculture, Quezon City, Philippines. CountrySTATPhilippines. At: <http://bas.gov.ph>.

Brown E.O., Alo A.M.P., Cruz E.M., Venturina V.M., Villar E.C., Gabunada F.G. Jr and Lambio E.T. 2003. Financial analysis of the basket of technology options for goat worm control. In the TAG 443 Philippines M&E report. International Livestock Research Institute: Los Baños, Philippines.

DA–Livestock (Department of Agriculture–Livestock) 2007. Third National Goat and Sheep Congress. Grand Caprice, Cagayan de Oro City, Philippines.

Datuin J.M., Alcedo M.J.B., Calumpit M.G., Bueno J.P., Bragado J.W.A., Quinit E.M. and Romquillo L.L. 2005. Enhancing goat production in Region 1. DA–RFU 1, ILIARC, DMMSU. Bacnotan, La Union, Philippines.

— 2007. Enhancing goat production through public and private partnership in Region 1. DMMSU: Bacnotan, La Union, Philippines.

Davis J.S. 1994. Disaggregation rather than mathematical manipulation for incorporating research impacts on supply. Working Paper No. 3. ACIAR: Canberra.

FAO (Food and Agriculture Organization of the United Nations) 2007. Livestock statistics. FAOSTAT at: <http://www.fao.org/es/ess/rm.live.asp>.

Gabunada F.G. Jr, Alo A.M.P., Villar E.C., Venturina V.M. Cruz E.M. and Lambio E.T. 2003. Harnessing essential agencies to sustain efforts on goat worm control: experiences of the TAG 443: Philippine project. P. 18 in 'TAG 443: Philippines M&E report'. ILRI: Los Baños.

Gordon J. and Davis J. 2007. ACIAR impact assessment, guidelines for practitioners. ACIAR: Canberra.

Gray G.D., Yee C.A.T. and Villar E.C. 1999. Philippine literature on helminth control for small ruminants. SPC Working Paper No. 2. ILRI: Los Baños, Philippines.

Hood G.M. 2004. Anthelmintic resistance in small ruminant parasites: implications for smallholders in Southeast Asia. Pp. 51–58 in 'Worm control for small ruminants in tropical Asia', ed. by R.A. Sani, D.G. Gray and R.L. Baker. Monograph No. 113. ACIAR: Canberra.

Howlader M.M.R., Capitan S.S., Eduardo S.L. and Roxas N.P. 1997a. Effects of experimental *Haemonchus contortus* infection on red blood cells and white blood cells of growing goats. Asian–Australasian Journal of Animal Sciences 10, 679–682.

Howlader M.M.R., Capitan S.S., Eduardo S.L., Roxas N.P. and Sevilla C.C. 1997b. Effects of stomach worm (*Haemonchus contortus*) infection on the kids born of infected mother goats. Asian–Australasian Journal of Animal Sciences 10, 435–438.

— 1997c. Performance of growing goats experimentally infected with stomach worm (*Haemonchus contortus*). Asian–Australasian Journal of Animal Sciences 10, 534–539.

ILRI–IFAD–PCARRD (International Livestock Research Institute – International Fund for Agricultural Development – Philippine Council for Agriculture, Forestry and Natural Resources Research and Development) 2003. Community-based participatory approach to the integrated control of gastrointestinal parasites in goats: The Philippine M&E report. ILRI–IFAD–PCARRD: Philippines.

— 2005. Technical Assistance Grant 443: Development and testing of an integrated approach to the control of gastrointestinal parasites of small ruminants in south and Southeast Asia, Terminal Report, September 2005. ILRI–IFAD–PCARRD: Philippines.

McLeod R.S. 2004. The economic impact of worm infections in small ruminants in Southeast Asia, India and Australia. Pp. 23–48 in 'Worm control for small ruminants in tropical Asia', ed. by R.A. Sani, D.G. Gray and R.L. Baker. Monograph No. 113. ACIAR: Canberra.

PCARRD (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development) 2007. Profitability analysis: 25-doe-level goat production. PCARRD: Los Baños, Laguna, Philippines.

PCARRD:DOST, DA–BAR (Philippine Council for Agriculture, Forestry and Natural Resources Research and Development, Bureau of Agricultural Research of the Department of Agriculture) 2006. The 2003 Goat Farming Committee. The Philippine recommends for goat farming. PCARRD:DOST, DA–BAR: Los Baños, Laguna. (Philippine Recommends Series No. 24-G).

Que E.I., Tongson M.S. and Acedo R.A. 1995. Cost–benefit analysis of deworming livestock at barangay level I. Deworming of goats at barangay level. Journal of the Philippine Veterinary Medical Association 1, 13–17.

Sani R.A. and Gray G.D. 2004. Worm control for small ruminants in Southeast Asia. Pp. 3–20 in 'Worm control for small ruminants in tropical Asia', ed. by R.A. Sani, D.G. Gray and R.L. Baker. Monograph No. 113. ACIAR: Canberra.

Sani R.A., Gray D.G. and Baker R.L. (eds) 2004. Worm control for small ruminants in tropical Asia. Monograph No. 113. ACIAR: Canberra.

Villar E.C., Domingo S.N., Porciucula F.L., Orden E.A., Dela Cruz N., Lilagan M., Datuin J., Idos A., Robeniol A., Plado T., Noche A., Fabia A., Pinto P., Dulay R., Dimaano A. and Antalan R. 2004. CASREN Philippines (CASREN Phase II) final country report: 2002–2004, Improving crop–livestock production systems in rainfed areas of South East Asia. PCARRD: Los Baños, Philippines. (In-house publication)

Appendix. Exchange rates, deflators and discount rates

	Exchange rates			Australian GDP deflator	Philippine deflator	5%
	A$:PHP	US$:A$	US$:PHP			
1983	10.01	1.11	11.11	40.9	11.4	3.23
1984	14.65	1.14	16.70	44.1	17.5	3.07
1985	12.99	1.43	18.61	46.3	20.6	2.93
1986	13.63	1.50	20.39	48.9	21.2	2.79
1987	14.40	1.43	20.57	52.3	22.8	2.65
1988	16.48	1.28	21.09	56.8	25.0	2.53
1989	17.19	1.26	21.74	62.2	27.3	2.41
1990	18.98	1.28	24.31	65.6	30.7	2.29
1991	21.40	1.28	27.48	67.9	35.8	2.18
1992	18.74	1.36	25.51	69.2	38.7	2.08
1993	18.44	1.47	27.12	70.1	41.4	1.98
1994	19.31	1.37	26.42	70.8	45.5	1.89
1995	19.06	1.35	25.71	71.6	49.0	1.80
1996	20.52	1.28	26.22	73.2	52.7	1.71
1997	21.87	1.35	29.47	74.3	56.0	1.63
1998	25.69	1.59	40.89	75.2	61.9	1.55
1999	25.22	1.55	39.09	75.3	66.8	1.48
2000	25.62	1.72	44.19	76.8	71.1	1.41
2001	26.37	1.93	50.99	80.5	75.6	1.34
2002	28.04	1.84	51.60	82.8	79.0	1.28
2003	35.15	1.54	54.20	85.2	81.9	1.22
2004	41.21	1.36	56.04	88.1	87.0	1.16
2005	42.07	1.31	55.09	91.6	92.6	1.10
2006	38.64	1.33	51.31	96.0	97.1	1.05
2007	38.64	1.20	46.55	100.0	100.0	1.00

Source: Gordon and Davis (2007)

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No.	Author(s) and year of publication	Title	ACIAR project numbers
1	Centre for International Economics (1998)	Control of Newcastle disease in village chickens	8334, 8717 and 93/222
2	George, P.S. (1998)	Increased efficiency of straw utilisation by cattle and buffalo	8203, 8601 and 8817
3	Centre for International Economics (1998)	Establishment of a protected area in Vanuatu	9020
4	Watson, A.S. (1998)	Raw wool production and marketing in China	8811
5	Collins, D.J. and Collins, B.A. (1998)	Fruit fly in Malaysia and Thailand 1985–1993	8343 and 8919
6	Ryan, J.G. (1998)	Pigeon pea improvement	8201 and 8567
7	Centre for International Economics (1998)	Reducing fish losses due to epizootic ulcerative syndrome—an ex ante evaluation	9130
8	McKenney, D.W. (1998)	Australian tree species selection in China	8457 and 8848
9	ACIL Consulting (1998)	Sulfur test KCL–40 and growth of the Australian canola industry	8328 and 8804
10	AACM International (1998)	Conservation tillage and controlled traffic	9209
11	Chudleigh, P. (1998)	Post-harvest R&D concerning tropical fruits	8356 and 8844
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13	Chudleigh, P. (1999)	Breeding and quality analysis of rapeseed	CS1/1984/069 and CS1/1988/039
14	McLeod, R., Isvilanonda, S. and Wattanutchariya, S. (1999)	Improved drying of high moisture grains	PHT/1983/008, PHT/1986/008 and PHT/1990/008
15	Chudleigh, P. (1999)	Use and management of grain protectants in China and Australia	PHT/1990/035
16	McLeod, R. (2001)	Control of footrot in small ruminants of Nepal	AS2/1991/017 and AS2/1996/021
17	Tisdell, C. and Wilson, C. (2001)	Breeding and feeding pigs in Australia and Vietnam AS2/1994/023	
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22	Bauer, M., Pearce, D. and Vincent, D. (2003)	Saving a staple crop: impact of biological control of the banana skipper on poverty reduction in Papua New Guinea	CS2/1988/002-C
23	McLeod, R. (2003)	Improved methods for the diagnosis and control of bluetongue in small ruminants in Asia and the epidemiology and control of bovine ephemeral fever in China	AS1/1984/055, AS2/1990/011 and AS2/1993/001
24	Palis, F.G., Sumalde, Z.M. and Hossain, M. (2004)	Assessment of the rodent control projects in Vietnam funded by ACIAR and AUSAID: adoption and impact	AS1/1998/036

No.	Author(s) and year of publication	Title	ACIAR project numbers
25	Brennan, J.P. and Quade, K.J. (2004)	Genetics of and breeding for rust resistance in wheat in India and Pakistan	CS1/1983/037 and CS1/1988/014
26	Mullen, J.D. (2004)	Impact assessment of ACIAR-funded projects on grain-market reform in China	ANRE1/1992/028 and ADP/1997/021
27	van Bueren, M. (2004)	Acacia hybrids in Vietnam	FST/1986/030
28	Harris, D. (2004)	Water and nitrogen management in wheat–maize production on the North China Plain	LWR1/1996/164
29	Lindner, R. (2004)	Impact assessment of research on the biology and management of coconut crabs on Vanuatu	FIS/1983/081
30	van Bueren, M. (2004)	Eucalypt tree improvement in China	FST/1990/044, FST/1994/025, FST/1984/057, FST/1988/048, FST/1987/036, FST/1996/125 and FST/1997/077
31	Pearce, D. (2005)	Review of ACIAR's research on agricultural policy	
32	Tingsong Jiang and Pearce, D. (2005)	Shelf-life extension of leafy vegetables—evaluating the impacts	PHT/1994/016
33	Vere, D. (2005)	Research into conservation tillage for dryland cropping in Australia and China	LWR2/1992/009, LWR2/1996/143
34	Pearce, D. (2005)	Identifying the sex pheromone of the sugarcane borer moth	CS2/1991/680
35	Raitzer, D.A. and Lindner, R. (2005)	Review of the returns to ACIAR's bilateral R&D investments	
36	Lindner, R. (2005)	Impacts of mud crab hatchery technology in Vietnam	FIS/1992/017 and FIS/1999/076
37	McLeod, R. (2005)	Management of fruit flies in the Pacific	CS2/1989/020, CS2/1994/003, CS2/1994/115 and CS2/1996/225
38	ACIAR (2006)	Future directions for ACIAR's animal health research	
39	Pearce, D., Monck, M., Chadwick, K. and Corbishley, J. (2006)	Benefits to Australia from ACIAR-funded research	FST/1993/016, PHT/1990/051, CS1/1990/012, CS1/1994/968, AS2/1990/028, AS2/1994/017, AS2/1994/018 and AS2/1999/060
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41	ACIAR (2006)	ACIAR and public funding of R&D. Submission to Productivity Commission study on public support for science and innovation	
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No.	Author(s) and year of publication	Title	ACIAR project numbers
47	Fisher, H. and Gordon, J. (2007)	Improved Australian tree species for Vietnam	FST/1993/118 and FST/1998/096
48	Longmore, C., Gordon, J., and Bantilan, M.C. (2007)	Assessment of capacity building: overcoming production constraints to sorghum in rainfed environments in India and Australia	CS1/1994/968
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50	Monck, M. and Pearce, D. (2007)	Improved trade in mangoes from the Philippines, Thailand and Australia	PHT/1990/051 and CS1/1990/012
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53	Monck M. and Pearce D. (2008)	The impact of increasing efficiency and productivity of ruminants in India by the use of protected-nutrient technology	AH/1997/115
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55	Martin G. (2008)	ACIAR fisheries projects in Indonesia: review and impact assessment	FIS/1997/022, FIS/1997/125, FIS/2000/061, FIS/2001/079, FIS/2002/074, FIS/2002/076, FIS/2005/169 and FIS/2006/144
56	Lindner, B. and McLeod, P. (2008)	A review and impact assessment of ACIAR's fruit-fly research partnerships – 1984 to 2007	CS2/1983/043, CS2/1989/019, CS2/1989/020, CS2/1994/003, CS2/1994/115, CS2/1996/225, CS2/1997/101, CS2/1998/005, CS2/2003/036, CP/2007/002, CP/2007/187, PHT/1990/051, PHT/1994/133, PHT/1993/87, CP/1997/079, CP/2001/027 and CP/2002/086
57	Montes N.D., Zapata Jr N.R., Alo A.M.P. and Mullen J.D. (2008)	Management of internal parasites in goats in the Philippines	AS1/1997/133

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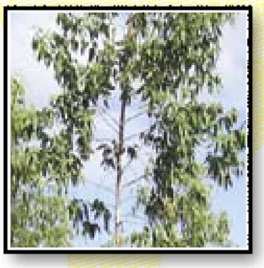
Management of internal parasites in goats in the Philippines



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