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Returns to investments in small ruminant research in Indonesia The Small Ruminant Collaborative Research Support Program (SR-CRSP) in West Java

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Abstract

Small ruminant research carried out by the SR-CRSP on management, nutrition and reproduction was developed and evaluated through an Outreach Pilot Program in West Java, Indonesia. On-farm testing indicated that introduction of different management practices could increase birth rate and survivability of Javanese Thin Tail sheep. This article presents results from an assessment of research investments that measures the potential returns from this technological package, with various adoption and spillover effects, weighs the benefits against the research and training costs of the SR-CRSP, and looks at distribution of benefits among consumers and producers of sheep in Indonesia. The rate of return in the most conservative scenario was 19%, with potential short-run benefits exceeding the costs incurred by breeding and nutrition research, and training of 23 masters and doctoral students in 10 years. Market conditions favor producers in the distribution of benefits.

1. Introduction

Studies that measure the returns to livestock research investments in developing countries are limited. Most are concerned with commercial production (dairy, forages, beef and poultry); few deal with subsistence producers. Collaborative Research Support Programs (CRSP), created with AID funding during the 1970s and 1980s, targeted problems of limited-resource farmers. The Small Ruminant CRSP (SR-CRSP) recognized that many such farmers often raise small ruminants as a complementary or sole activity. Traditionally these farmers do not have access to government services and cannot influence policy of decision making.

This article measures the returns to investments in the West Java SR-CRSP program by focusing on the benefits of a management, nutrition, and reproduction technological package tested through the Outreach Pilot Program (OPP), and the costs of the research and training program between 1980 and 1991. The purpose is to determine if the short and medium-term benefits of this package fund the long-term breeding research and the training programs, and the distribution of these benefits. After a brief description of the program and some methodological considerations, the demand and supply of sheep and goat-meat in Indonesia, the production characteristics and experiences with the OPP are presented. A brief review of the

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economic surplus model, the data and coefficients used to measure returns follows. Finally, different scenarios on adoption are presented and the returns calculated. Other difficult to measure benefits resulting from the program are presented.

2. The SR-CRSP in West Java

North Carolina State University (Animal Nutrition), University of Missouri-Columbia (Sociology), Winrock International (Economics) and the University of California, Davis (Breeding), collaborated with the Indonesian Research Institute for Animal Production (RIAP) in a comprehensive research and human capital development program to develop technologies that enhance small ruminant production through the SR-CRSP. Prolific sheep in West Java was the research focus between 1981 and 1991, and hair sheep in rubber plantations in North Sumatra between 1990 and 1996. This study measures the returns to investments in the first one.

Several points must be considered when assessing the impact of the SR-CRSP on the development of small ruminant technologies: the research process and technology development; the marginal conditions under which small ruminants are produced; the potentially high risks faced by producers; and the institutional strengthening expected through development of human capital.

Evaluation of the Indonesian program presents challenges because it encompasses basic research, development research, and human capital development. As a result, there are considerable lags between investments and measurable benefits through adoption by producers. Expected lags in nutrition and reproduction research vary between 5 and 10 years, and are longer in the case of genetic improvement. Lags between training and impact of developed human capital are at least 7 years, and often difficult to measure.

3. Sheep in West Java

Sheep are an important complementary income-producing activity in densely populated areas of Indonesia such as West Java, providing between 15 and 25% of family income. These may be found on one in five farms throughout Indonesia. There were 1,317,900 Indonesian households raising sheep in 1983, with 841,000 of these households located in West Java (De Boer, 1985). Families are involved in raising small ruminants, with women and children playing prominent roles in feeding. Selling and buying animals, on the other hand, is an activity dominated by males. Women have a higher participation rate in livestock activities when the household is poorer and no other employment opportunities exist.

4. Potential demand for meat

The population of Indonesia has grown from 147.5 million in 1980 to 187.2 million in 1993 with an average growth rate of 1.7% (World Bank, 1995). Income and population growth are primary determinants of the demand for red meat, which is projected to remain strong for sheep and goats (Knipscheer et al., 1994). Dramatic increases in demand are typical during Idul Adha, an Islamic holiday, when prices can double or even triple. There is also potential for demand from the Middle East, though export of live animals and meat processing face limitations.

Meat accounts for 25% of non-plant protein in the diets of consumers in rural areas. Per capita consumption of red meat in Indonesia remains low, 4.01 kg in 1990, indicating a potential for substantial growth as income increases (Knipscheer et al., 1994). Price trends also indicate a strong demand for red meats. Prices tripled between 1977 and 1982, and the differential between red meat and poultry prices continues to increase. This is important because increased income[1] and demand for meat contribute to income redistribution from urban to rural areas.

5. Sheep production

The 1987 population of sheep in Indonesia, based on the household survey by SUSENAS, was estimated

[1]Income elasticity for meats in Indonesia were estimated by several authors. Sabrani's estimate from time series data in 1979 was 2.08; the estimate for mutton by Chernichovsky and Meesook in 1984 (Knipscheer et al., 1987) from cross-section data was 1.2. Other elasticities are quoted in Knipscheer et al., 1987. Sarma, 1986 estimated an income elasticity of mutton of 1.6.

at 5,364,000 head. Of these sheep, 2,423,000 were in West Java and 1,249,000 were in Central Java. Estimates developed by an AARD-ISNAR[2] study show meat supply in West Java growing from 8,096 MT in 1983 to 10,264 MT in 1988, a 27% increase in 5 years. A major source is the Javanese Thin-Tail (JTT) sheep raised mostly under a zero-grazing or cut-and-carry system. The average sheep producer has five to six animals. Supply of animal feed is constrained by the collection ability of the household and by the size of the farm. In Garut, West Java, for example, feed is composed of grasses (80%), tree leaves (8.5%), and agricultural by-products (9%) from rice and bean straw, cassava and corn leaves, and shrubs (2%) (Suparyanto et al., 1992).

The average litter size is high, (1.7 lambs), but so is mortality when triplets and quadruplets are born. On average, there are 14 rams per 100 ewes in West Java. In many cases rams are borrowed for the mating season. Actual and potential productivity coefficients are presented in Table 1. 'Actual' is the productivity at the village level and 'potential' is obtained at the research station. Both the lambing interval and pre-weaning mortality (which varies from 5 to 39%), can be reduced by improved management practices.

The potential increase of West Java's sheep supply depends on two sources. The first is improving management with alternative nutrition, reproduction and health practices. The second is by adjusting the prolificacy potential of sheep to available feed resources (Gatenby et al., 1988), to reduce mortality, especially at lambing and before weaning.

Table 1
Actual and potential productivity coefficients for Javanese Thin Tail Sheep

	Actual	Potential	Ratio
Litter size	1.4	1.8	0.78
Lambing interval (d)	520	240	0.46
Age first lambing (d)	500	420	0.84
Survival to 90 days (%)	74	85	0.77
Pre-weaning growth (g/d)	67	85	0.67
Weaning weight (kg)	8.30	12.0	0.69
Weaning rate (per year)	0.73	2.32	0.31
Productivity per year (%)	27	110	0.29
Body weight at puberty (kg)	17–20		

Source: Gatenby, R.M., Jensen, R.A.C., Subandriyo and Bradford, G.E. 1988. 'Actual and Potential performance of Indonesian Sheep and Goats Under Traditional Management Systems' SR-CRSP Technical Report No. 97.

6. The Outreach Pilot Project (OPP)

Small ruminant production in peasant household systems is often constrained by management, environmental, and genetic factors. Animal productivity is generally low, reflected by low body weights, high pre-weaning mortalities, long lambing/kidding intervals, and the unavailability of rams/bucks for breeding (Ludgate et al., 1990). The OPP was a research, extension, and assessment effort carried out in 15 villages of Bogor, West Java, that brings together the expertise and insights of all four biological and social sciences projects.

7. Technological improvements

Three functions were expected of the OPP: (1) a testing ground for new technologies; (2) a demonstration farm to spread knowledge; and (3) a breeding multiplication center. An evaluation of the OPP's 5-years on-farm testing (Ludgate et al., 1990) shows that lamb mortality rates decreases from 20.5% to 9.3% in the first year, and rises to 11% afterwards. The minimum lambing interval decreases to 240 days, as compared to 360–450 days under traditional animal management. The shorter lambing interval allows for three lambings in 2 years, instead of the traditional one lambing a year, a 50% increase in yield per ewe (Setiadi and Iniguez, 1990). In many cases absence of rams is a problem, which is addressed by a sharing system to reduce this lambing cycle. The first socio-economic evaluation (Priyanti et al., 1988) points out

[2]Philip Pardey, Senior Officer, ISNAR: Regional Research Project Asia. 'Priority Setting Mechanisms for National Agricultural Research: Indonesia Study,' AARD-ISNAR. International Service for National Agricultural Research. An important set of data was provided by Dr. Philip Pardey at the International Service for National Agricultural Research (Bahri et al., 1991), who was at the time working with the Central Bureau of Statistics (SUSENAS) of government of Indonesia on the ex-ante evaluation of research in agriculture.

that 88% of the farmers agree with the proposed sharing system. This on-farm research and development model provides support to the contention that farmers should actively participate throughout the technology development process (Ludgate et al., 1990).

8. Technology adoption

Monitoring of the farmers' management, feeding and marketing practices takes place throughout the existence and after termination of the OPP. Recommended feeding and management practices (Martawidjaja et al., 1990) are developed and tested. These include four technological packages: barn separation by physiological status and feeding regime; roughage feeding throughout the year; provision of salt and water; and legume tree planting (Yulistiani et al., 1989). The evaluation of the nutrition tech pack (Haryanto et al., 1990), shows seasonal variation in the adoption of feeding practices, especially in the provision of water and salt. Barn separations by physiological status and improved barn management recommendations are adopted by 88% of the farmers. Adoption of *Gliricidia Maculata* by OPP farmers (Bilinsky and Gaylord, 1992) grows from 7 to 67% in 2 years, as a supplement to basal diets. Some limiting factors in adoption are scarce supply of trees and of land.

Practices are adopted in varying degrees as the monitoring showed. These fluctuate from 5 to 88% depending on the season and the nature of the technique, resulting in the average yields reported above. A survey, six months after the closing of the OPP (Soedjana, Priyanti and Mujchi, unpublished), shows 84% of the farmers providing enough feed, 40% feeding grasses and tree legumes or grasses with supplements, while 48% of the farmers provide grasses and agricultural by-products. Feed is provided fresh 84% of the time, salt is available 48% of the time, and water (clean in the bucket) 28%. Barn separation and soundness is practised by 44% for the four separation options. In summary most studies report adoption rates of at least 40%, with the exception of watering. Similar results are reported by scientists in interviews conducted in 1992 (Valdivia, 1992).

9. A methodological approach to measuring returns

The choice of method to measure returns to research investments is constrained by the available data, and depends on the type of answers being pursued. Two traditional approaches often used are the econometric that treats research expenditures as a variable, and may be estimated with a production function, measuring the marginal returns on investment and requiring time series data. The economic surplus model, a second approach, estimates average returns by determining the movement or shift of the supply function. It measures ex-ante or ex-post benefits, does not require long time series of data, and provides information on who benefits from the research (Norton and Davis, 1981; Echeverría, 1990; Alston et al., 1995). The effect of economic policies that change the relative prices at the producer and consumer levels can be estimated with this method, as well as the impact of changing adoption patterns.

Assessment studies of research investments on crops in developing countries easily outnumber those on livestock and forages (Echeverría, 1990). Most of the livestock (dairy, beef and pastures) studies concentrate on the United States, Canada and Australia. Few exist on developing countries. A study of improved sheep technologies in Bolivia (Wennergren and Whitaker, 1977) reports returns that fluctuate between 44 and 48%. An ex-ante evaluation on pastures in Latin America (Seré and Jarvis, 1990) yields 15 to 20% returns with an 11-year lag. An econometric ex-post evaluation study of the Indonesian Agency of Agricultural Research and Development (AARD) on the impact of research on crops, perennials and livestock for the period 1982–1992 (Evenson et al., 1994), is unable to identify the impacts of research on livestock (meat and milk aggregates), (Evenson et al., 1994), suggesting need for further evaluations.

10. Evaluation of the SR-CRSP's OPP investments

An evaluation of the OPP (Ludgate et al., 1990) technological package estimates that adoption would increase the production of lambs by 1.7 million. This study assumes a population of 2 million adult ewes in West Java, one lamb per parturition and a survival rate of 85%. It also assumes 100% adoption by the farmers, which is very unlikely (Alston et al., 1995). The alternative evaluation proposed here, an economic surplus model, measures the potential impact of the SR-CRSP investment, as the research product is complete but the diffusion pattern is just starting. It is useful because it measures the potential benefits to producers, the ultimate target of the SR-CRSP, through the OPP, and allows simulation of different adoption patterns.

The costs stream in this study includes research and graduate degree training, as well as the costs of the breeding research program on high prolific sheep in Java between 1980 and 1991. The derived benefits from the last two are not included because lags exist. This approach determines if the short-term benefits of improved sheep management, reproduction and nutrition practices, offset the costs of activities in the program with long lags between investment and impacts.

11. Estimating the returns to research for producers and consumers

The economic surplus model (Alston et al., 1995), used for ex-post studies or research priority setting, requires estimates of commodity-specific price elasticities of supply and demand, quantities traded internationally (if there is an open economy), and agricultural policies. The assumption of constant prices in standard benefit cost analysis is dropped, and market conditions are introduced (Alston et al., 1995). Total, consumer, and producer surplus are calculated as a function of base prices and quantities, demand and supply elasticities, and the vertical shift in the supply curve result of the innovation, measured as a unit cost reduction (Alston et al., 1995). Parallel shifts are assumed in this case. The equations follow:-

Change in consumer surplus:

$$\mathrm{CS}' = PQZ(1 + 0.5Zn)$$

Change in producer surplus:

$$\mathrm{PS}' = PQ(K - Z)(1 + 0.5Zn)$$

where:

Z	$(Ke)/(e + n)$;
e	Price elasticity of supply;
n	Own price elasticity of demand;
K	Vertical shift of supply function expressed as percentage of initial price;
P	Original price;
Q	Original quantity;
$'$	Change (in percent or deviation of a function).

To estimate the cost change, K (where K is the vertical shift of the supply curve), the yield change due to the technology, the change in cost of production, the probability of success of the research (if this has not been completed), as well as estimates of adoption rate, are required. K is calculated by determining the unit change in the cost of production due to the introduction of the new technology at the original level of production.

The natural increase in demand every year is equal to:

$$D = p + mg$$

where p is the growth rate of the population, m is the income elasticity of demand, and g is the growth rate of per capita GDP. Both income and population growth shift the demand each year. Adoption of technology shifts the supply. These shifts take place until the adoption ceiling has been reached. The market for mutton is assumed to be closed; currently no exports are taking place though some took place in the past.

12. The data

Quantities and prices for a base year were gathered from secondary sources. Interviews with scientists were used to determine yield changes, cost factors, research success, adoption rate, and adoption ceilings. Income and own-price elasticities of demand and supply were obtained from various studies, and reviews. Projections of population and income growth from World Development Report 1995, the Handbook of Economic Statistics (CIA) and Nolan et al. (1994) were used to calculate shifts in the demand. A population growth rate of 1.7 was used from 1980 to 2000, and 1.1 from 2001 to 2007. The coefficients and sources are listed in Table 2.

Research costs are obtained from the SR-CRSP Management Entity at the University of California,

Table 2
Data and coefficients used in the calculation of rates of return.

	Definition of the coefficient	Value	Source
e	Own-price elasticity of supply for sheep	0.3	San and Knipscheer (1994)
n	Own-price elasticity of demand for mutton	−1.03	Johnson et al. (1987)
		−1.61	Davis et al. (1987)
m	Income elasticity of demand for mutton	1.2	Knipscheer et al. (1987)
p	Population growth 1988–2000; 2001–2005	1.7	Nolan et al. (1994)
		1.1	
y	Per capita income growth rate 1980–1993	4.2	World Bank (1995)
K	Percentage unit cost reduction	0.25	Valdivia (1992)

Davis. Principal investigators from each participating institution are interviewed to identify the proportion of the budgets spent on the West Java Program. Total costs between 1980 and 1991 incurred by the West Java SR-CRSP are US $ 2,469,763 which includes research on high prolific sheep, and the expenses of 12 masters degrees and 11 PhD degrees. The costs of four full-time researchers borne by the Government of Indonesia are added[3] (De Boer, 1992).

13. Lags, cost change and assumptions

Site specificity and the recommendation domain are necessary to identify spillovers of small ruminant research to other geographical regions (Pardey and Wood, 1991). The method to predict adoption is based on expert interviews (Alston et al., 1995). RIAP researchers interviewed in 1992 are confident that the SR-CRSP technologies tested at the OPP can be adopted in other regions. They indicate that these technologies can be adopted by 50% of the farmers in West Java and Sumatra. The research lag, from the time the research is successfully completed to the time of implementation, is expected to last for 3 years for sheep management, 10 years for breeding/genetic improvement, and 4 years for animal health. Research lags elicited by Pardey and Wood[4] coincide with opinions of RIAP scientists interviewed for this study.

[3] I appreciate the suggestion of John De Boer to include these costs instead of using much higher estimates based on conducting research in the US.

[4] Personal communication in 1992 when they were conducting an assessment of the Indonesian RIAP. The lags between research and development coincided with information obtained from researchers at RIAP and experience at the OPP.

Cost reductions of a yield increase are calculated by computing yield changes, and additional inputs and barn construction required to obtain this yield, to net out the additional costs. Cost calculations are based on information from the OPP[5]. Additional costs per sheep on a yearly basis include drenching, barn separations, salt, and water buckets. The change in the unit cost of production with the new technologies and yields at the original level of production result in a change from 8,300 rupees per sheep to 6,155 rupees per sheep (Valdivia, 1992). This calculation assumes a yield change of 50% and a mortality rate of 11%. The per unit cost reduction (K) is 25%.

The following are assumptions made to calculate the rates of return to investments:

(1) The adoption rate peak by farmers in West Java is 20%, based on lower bound reports on some practices from the OPP adoption studies; (2) Ewes available for reproduction are 39.14% of the animals, based on the records kept by the OPP. Inventoried animals estimated for 1989 are used as the base; (3) Initial price is a weighted average price of rams and ewes reported by Soedjana and Priyanti (1990), that stated that 66% of the animals sold were male and 34% female. The price for a ram is 78,400 rupees, and for a ewe 72,250 rupees. These represent 66% of the sales. The remaining are younger animals sold at an average price of 46,150 rupees. The weighted average price is 65,500 rupees. An exchange rate of 2,265 rupee/dollar generates a price of US $ 28.91 per sheep, which is used as the base price for the calculations. Population growth rate changes from 1.7 to 1.1 in the year 2001; (4) All scenarios assume a research-adoption lag of 3

[5] Costs were calculated with Atien Priyanti, Agricultural Economist, RIAP.

Table 3
Adoption scenarios of SR-CRSP technologies and returns to research

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Conservative	Faster rate of adoption	Active extension	Spillover to other regions
Research lag	3 year	3 years	3 years	3 years
Years to 10% adoption	9	7	9	9
Adoption in 20 years	20%	20%	40%	20%
Adult ewes base (head)	1,143,000	1,143,000	1,143,000	1,204,000
Net present value	US$ 4,029,000	US$ 5,411,000	US$ 9,986,000	US$ 4,321,000
Rate of return	19%	22%	25%	20%

years since these are management related technologies (Pardey and Wood, 1991). The lag takes place between 1987 and 1990; and (5) The income elasticity chosen is 1.2 although there are other studies showing larger elasticities (Sarma, 1986). All these coefficients are listed in Table 2. Costs budgeted for West Java (Valdivia, 1992) start in 1980, and run through 1991 ranging from US $ 150,000 to almost US $ 400,000 a year.

14. Results and discussion

The economic surplus model is calculated assuming a closed economy with demand shifts[6]. The growth in demand is dominated by the changes in income and population. The former combined with high income elasticities contributes to a large shift to the right in the demand. The supply is affected by the level of adoption, a function of the lags and the expected time to reach maximum adoption, and by the unit cost reduction. The distribution of the surplus between producers and consumers is determined by the type of shift, parallel in this case, and the elasticities of demand and supply. An elastic demand and inelastic supply provide conditions for a distribution of surplus that favors producers, contributing to the redistribution of income from urban to rural areas through sheep sales. The benefit cost analysis spans 1980 through 2007. With information on maximum adoption rate, adoption lag of 3 years for management interventions, and a predicted adoption of 10% in 9 years, and maximum adoption of 20%, a logistic adoption function is calculated (Alston et al., 1995). For purposes of sensitivity analysis, additional adoption curves are calculated, a maximum 40% adoption with similar adoption patterns, and a 20% adoption by the year 2007, with a faster adoption to 10%. The scenarios are listed in Table 3. Acceptable levels in developed countries are around 10%, not accounting for inflation. The World Bank's range is between 8 and 15%, and USAID's is 11%.

[6]George Norton, VPI, provided the initial software that was adapted for calculations in Indonesia.

15. Adoption scenarios and returns

Scenario 1, the baseline rate of return calculation only considers adoption in West Java with a peak adoption of 20% in 2007, a 3-year lag between research and adoption and 9 years to reach 10% adoption. This is a conservative scenario because the maximum adoption is less than half of the predicted by the researchers. The second rate of return (Scenario 2) considers a faster adoption to 10%, 7 years. It is a scenario to show the impact of a more effective diffusion program. The third (Scenario 3) assumes a 9 year period to 10% adoption, as the baseline in terms of the adoption pattern, but considers a greater total adoption of 40% in 20 years. This simulates the conditions as reported by the researchers and by results form the OPP. The fourth rate of return calculated (Scenario 4) includes spillover effects to North Sumatra and Aceh, with a pattern of adoption that is similar to the baseline. The rates of return are presented in Table 3.

Scenario 1 yields an internal rate of return of 19%. The net present value of the benefits generated by the program, at 10%, is US $ 4 million. This baseline scenario yields a profitable investment. This is conservative because the lower bound in adoption is used, and all the costs of the SR-CRSP have been included in the cost stream. The returns from the OPP technological package alone, offset the costs of training and basic research activities. This means that the benefits from this management technology pay for the long term costs of human capital development and genetic research.

The purpose of scenario 2 is to look at the impact of a faster rate of adoption, in this case instead of taking 9 years to reach 10% adoption the lag is shorter, 7 years. In this scenario the rate of return increases by 3%, to 22%. The net present value increases by US $ 1.4 million. This highlights the importance of an effective extension program. Scenario 3 looks at the impact of a higher adoption, closer to the one predicted by the scientists and extension personnel working with the OPP. When the maximum is 40% in 20 years, the rate of return increases from 19 to 25%, and the net present value as compared to the baseline more than doubles. The 40% adoption is still lower than that observed at the OPP, it requires an active research and extension linkage in the development and demonstration phases. Scenario 4 considered the possibility that this technology can be used in other geographical areas with similar recommendation domains. Spillover has a small impact because sheep are a new activity, growing fast, but low in numbers. The rate of return increases by 1% because the base number of sheep that include Aceh and North Sumatra is only 5% of that in West Java.

The distribution of the surplus between consumers and producers, given the outlined market conditions favors the latter. Of the total surplus generated in a given year, 22.6% is consumer surplus and 77.4% is producer surplus. The analysis is based on farm gate prices. Given the market conditions and supply and demand coefficients, shifts due to technological change benefit producers. In other words, because meat is both an income and price elastic good, per capita income is rising, and the price elasticity of supply is low, shifts in the demand and supply function result in a distribution of the economic surplus that favors producers. Given these conditions, focus on small ruminant research to increase productivity is an effective mechanism to improve the welfare of resource poor rural families. Current market conditions favor an income redistribution process from consumers, usually in urban centers, to producers in the rural areas.

16. Policy implications

Favorable market conditions and an aggressive extension program will yield higher returns to investments. Sheep are an important commodity in West Java and of potential importance nationally according to the Master Plan for Animal Research and Development 1990–1995. Development and dissemination of research results are emphasized in the plan for 1990 to 1995, with 20% of the RIAP funds allocated to research in technology adoption. The objective is to increase the number of technical publications and brochures in the popular media, following the success of the technological packages developed through the OPP and used by extension in West Java. The technologies evaluated, as others developed by RIA,P have shown reasonable profitability and have been the result of working with farmers, extension staff and local authorities (De Boer, 1992). But in order for these to be adopted at high rates, other conditions are required. Besides an effective research program, there is need for a credit market supportive of small holder producers, functioning input and output markets, and government policies that foster development of this sector. New policies at AARD, are placing more emphasis in the private sector, agro-industry that may contribute to build linkages and cooperation with small holder producers. These support services are needed to accelerate progress in the livestock sector (IDRC, 1986; De Boer, 1992). De Boer (1992) concludes that if the livestock sector is to meet the goals of the government of Indonesia, the private sector has to become an active partner, especially in the technology adoption and transfer; and invest in more support services for smallholder producers.

17. Nonmeasured benefits

The evaluation of strategic research and human capital investments is difficult. The lag of human capital impact is one (Evenson et al., 1994). The Bean/Cowpea CRSP project evaluation (Schwartz et al., 1993) approximates the impact from training by measuring the savings of education versus the cost of importing expertise. Other benefits, not measured by this study but significant, should be mentioned. Institution building, the development of research capacity in the US and Indonesia, is an important product of this program. Graduate degree training funded by the SR-CRSP, included only as costs, represent between 20 and 25% of the researchers at RIAP in 1994 (Evenson et al., 1994). An important dimension is the inclusion of both biological and social sciences graduate degree training, which will strengthen the interdisciplinary research programs needed to target small holder farming systems. Research on prolific sheep (Gatenby et al., 1988) conducted by the breeding program discovered a prolific gene. A proposal for management conditions under high resource and low resource conditions has been developed to increase efficiency. The research approach developed by the OPP has been adopted in North Sumatra with the research program on hair sheep. These technologies are used in government transmigration program in areas near rubber plantations. Management technologies have been developed for goats in West Java. The potential impacts are not included in this study, though the costs of this research are. All these are other reasons why the returns measured in this study are considered the lower bound on possible returns.

18. Conclusions

The present project evaluation, which considered only the benefits of management, reproduction, nutrition and socio-economic research tested on-farm, showed positive returns to investment that can be triggered by an effective extension system. The rates were larger than those set by the World Bank and USAID, even when costs of training, breeding and basic research in West Java with the SR-CRSP were included, while measuring only the benefits of technologies tested at the OPP. This shows that technologies developed for small holder production systems alone can pay for the long term breeding research and human capital development required to sustain productivity in the future. Currently emphasis is being placed on the linkages between research and extension in Indonesia (De Boer, 1992).

A package developed and translated to local languages has been used widely by extension in Indonesia. Though there are reasons for optimism, a combination of favorable market conditions and the evaluation of scientists on the appropriateness of the technologies, as well as an observed high adoption in the villages participating in the Outreach Pilot Project, concerns remain on the effectiveness of the extension alone to facilitate such a high adoption. A close relation existed between OPP and extension, an important condition that has triggered adoption in other commodities (IDRC, 1986). The real challenge is to identify funding for research and diffusion activities that are not a strategic priority for the government, such as small ruminants. The move by AARD, agency under which RIAP functions, to strengthen ties with the private sector is a needed step in this direction.

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